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AUTHORITY

FAA notice, 2 Jul 1973

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PHASE III PROPOSAL

SUMMARY

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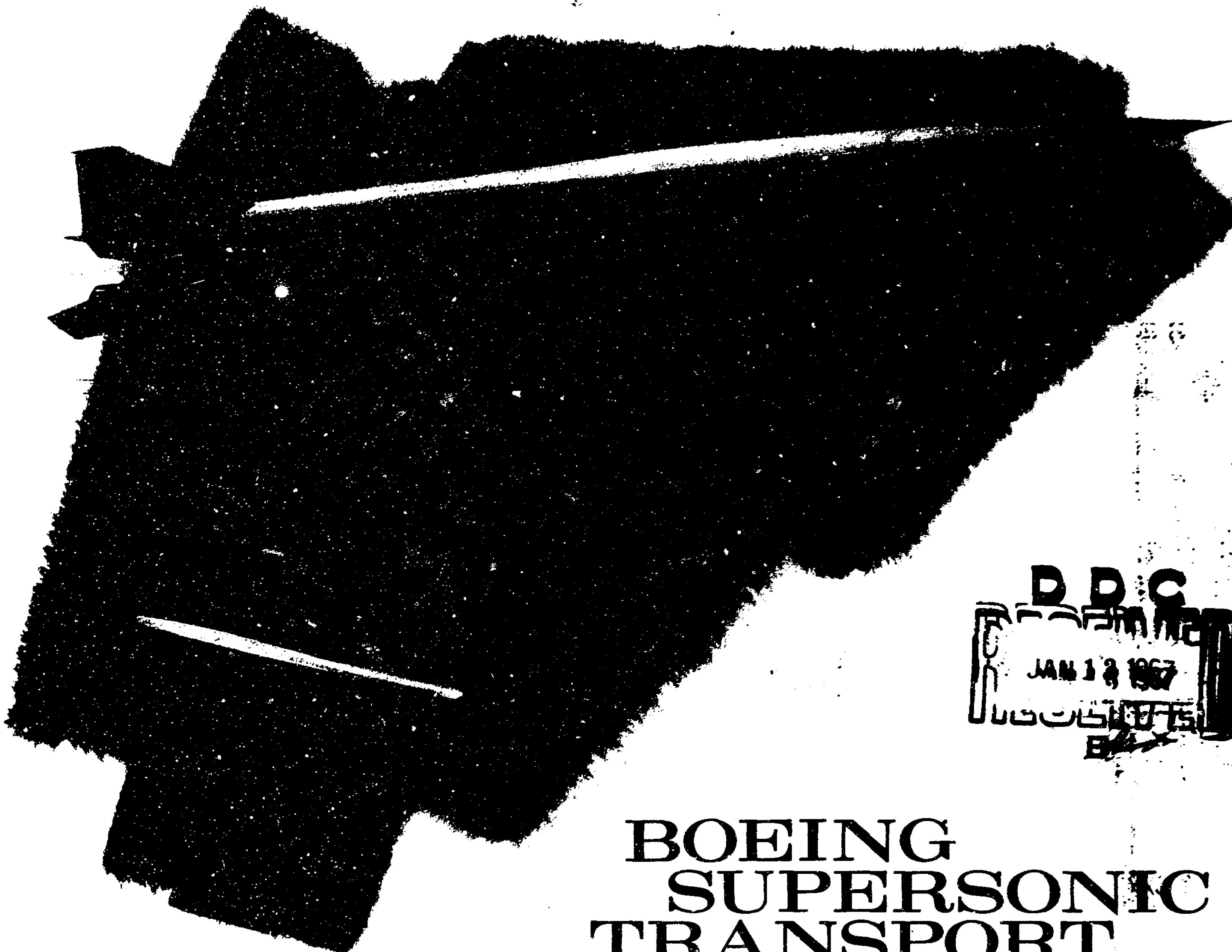

BOEING SUPERSONIC TRANSPORT

2

(6) Supersonic Transport Development Program , Phase III Proposal ,

BOEING MODEL 2707 , Volume I—1.

[redacted]

SUMMARY.

(14) **V1-B2707-1** **~~SEPTEMBER [redacted] 66~~**

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(12) 91p.

(15) [redacted] FA-SS-66-5

FEDERAL AVIATION AGENCY

Office of Supersonic Transport Development Program

ISSUE NO. ______________

CONTENTS

(402 097)

The Boeing USA-SST

The supersonic transport will come.

The technology required for development and construction of a safe, efficient, economical supersonic transport is now available.

Furthermore, the use of air transportation is expanding so rapidly that by the mid-1970's an airplane having the tremendous work capacity of the proposed Boeing SST will not only be economically sound – it will be an essential ingredient of the needed further expansion of the world's air transportation system.

The Boeing Company, a major producer of commercial air transports, is determined to become a part of that future.

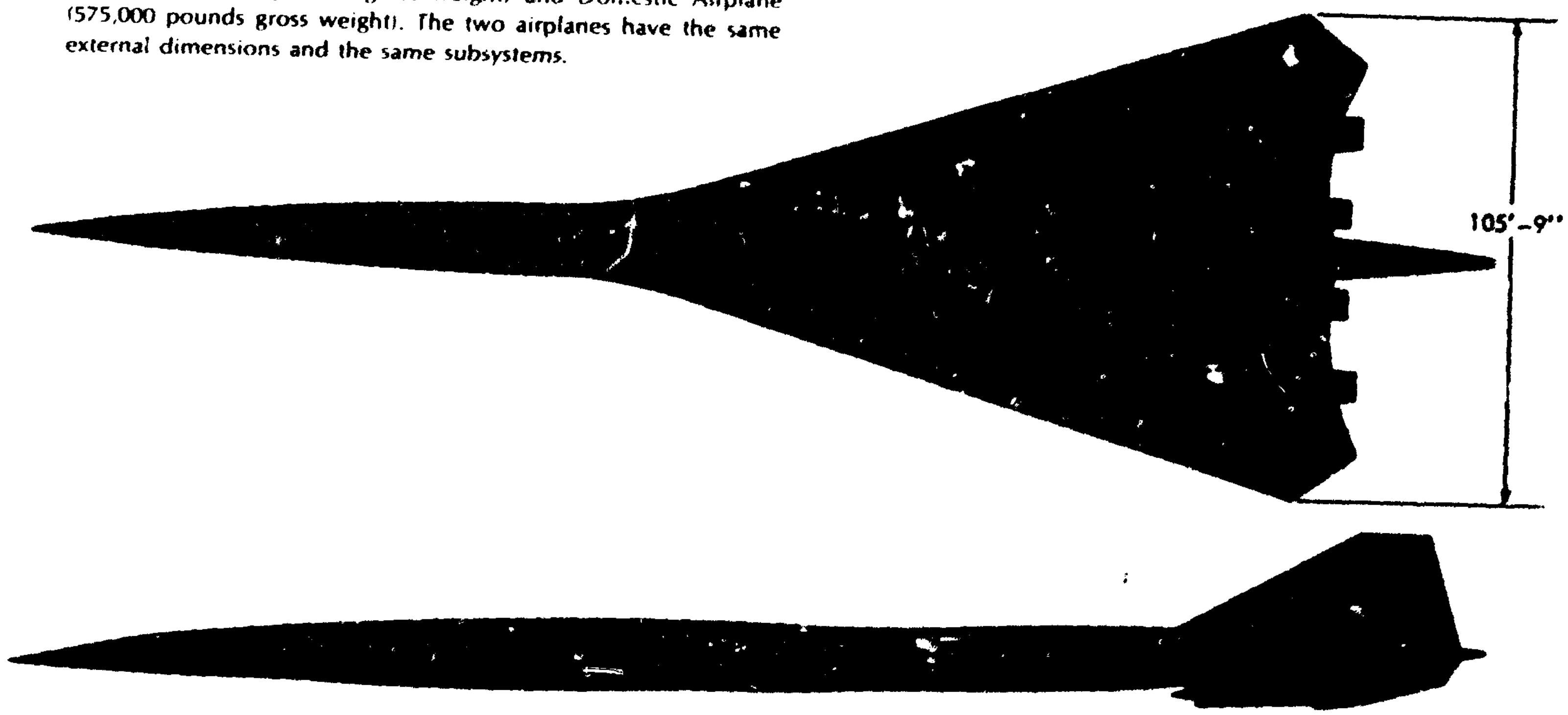
In studying the need for this type of airplane, Boeing has used both its intimate knowledge of the technical possibilities of various types of supersonic transports and its understanding of airline operational requirements. We believe that we have a sound understanding of the demands of a commercial airplane program. Each day, Boeing-built transports are taking off and landing at an average rate of one every 20 seconds. The need for near absolute safety and the

THE FUTURE ENVIRONMENT

The B-2707

The B-2707 is designed to cruise at Mach 2.7 and to have takeoff and landing characteristics similar to current jet transports. The B-2707 is a logical development, based on the experience gained in the production of a major segment of the world's airline transportation system. The B-2707 configuration and accommodations are presented below and on the following pages for the International Airplane (675,000 pounds gross weight) and Domestic Airplane (575,000 pounds gross weight). The two airplanes have the same external dimensions and the same subsystems.

1·1 *B-2707 Configuration—Wingsweep 72°*



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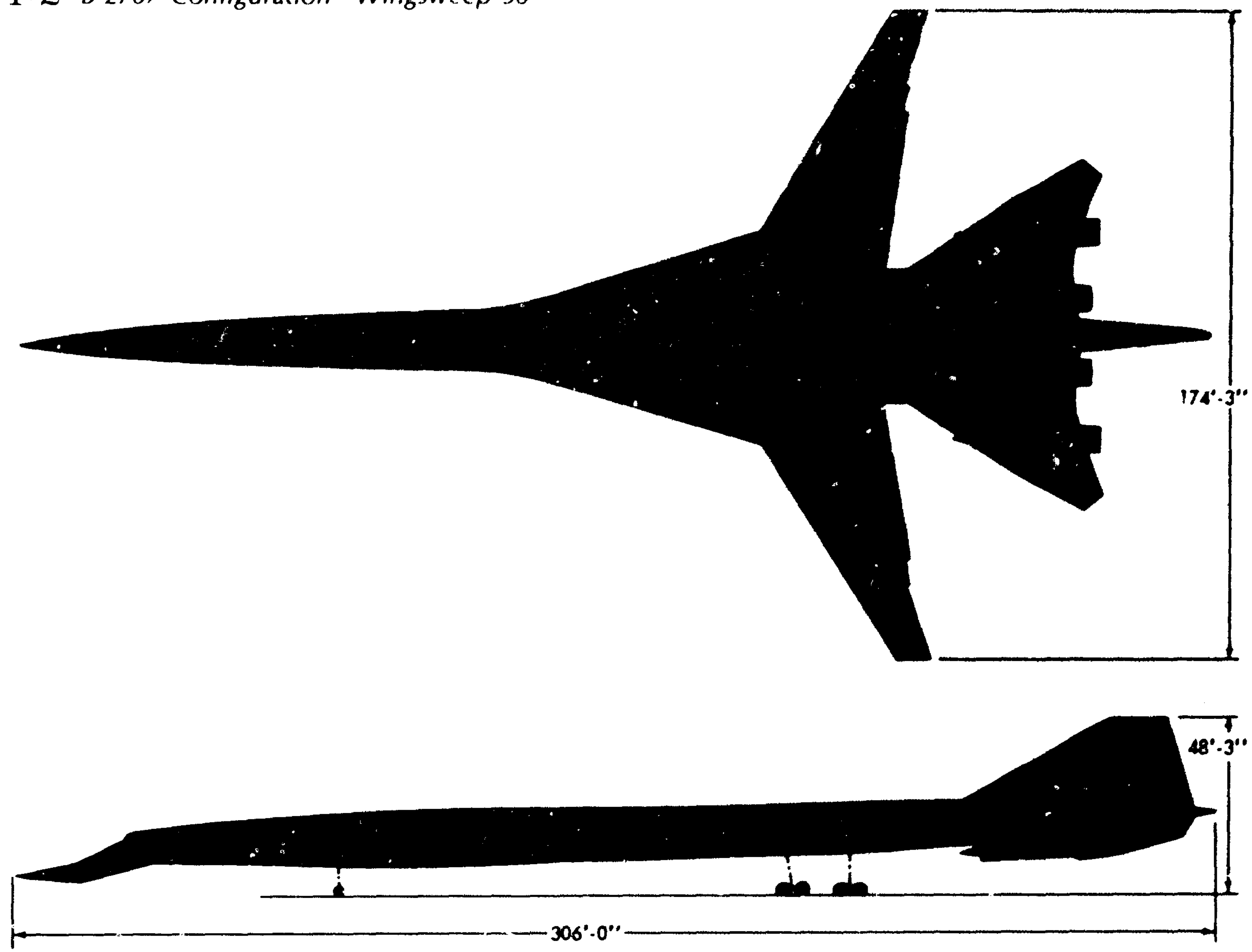
1•2 *B-2707 Configuration—Wingsweep 30°*



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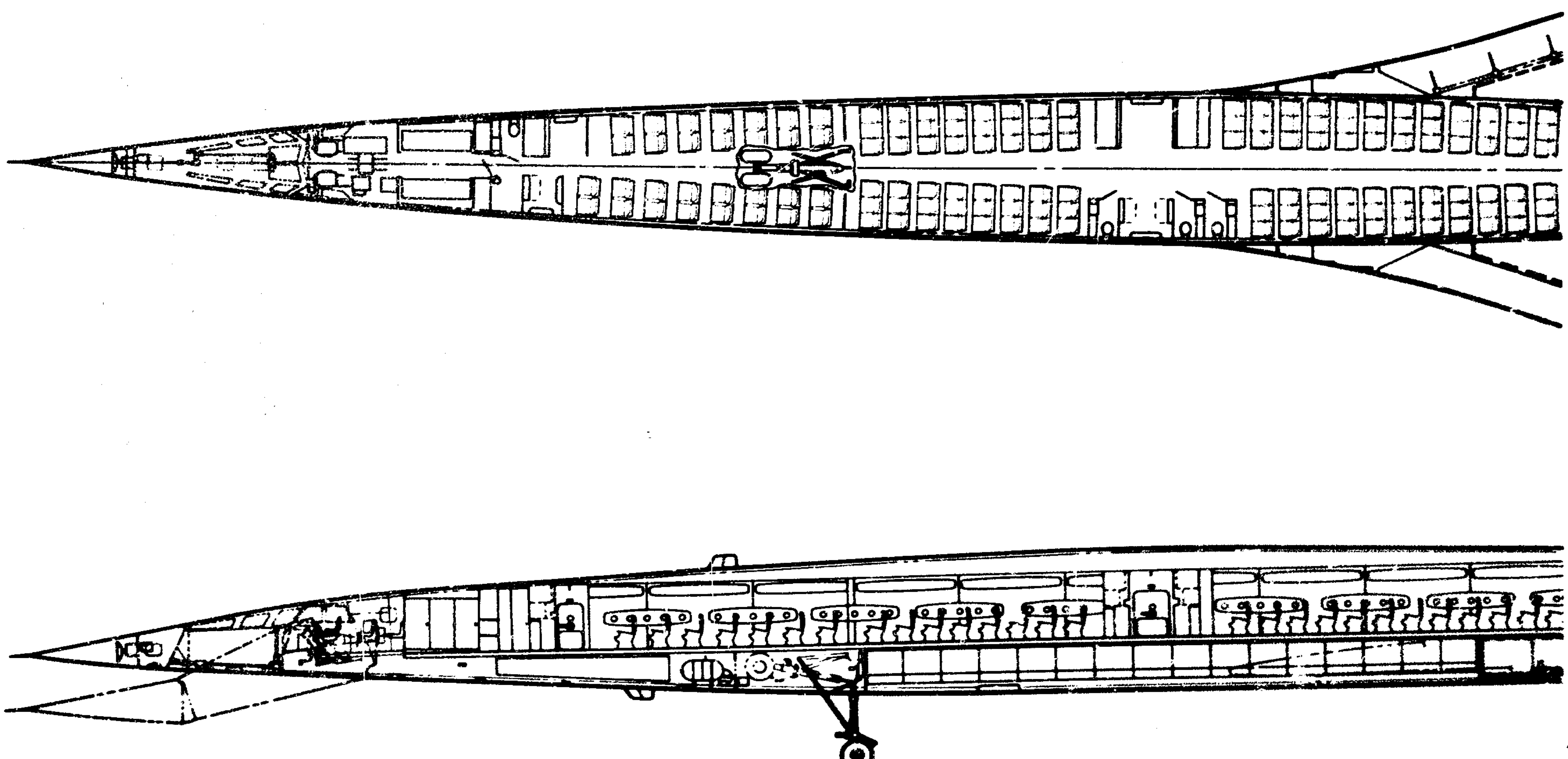
1·3 *B-2707 General Arrangement*



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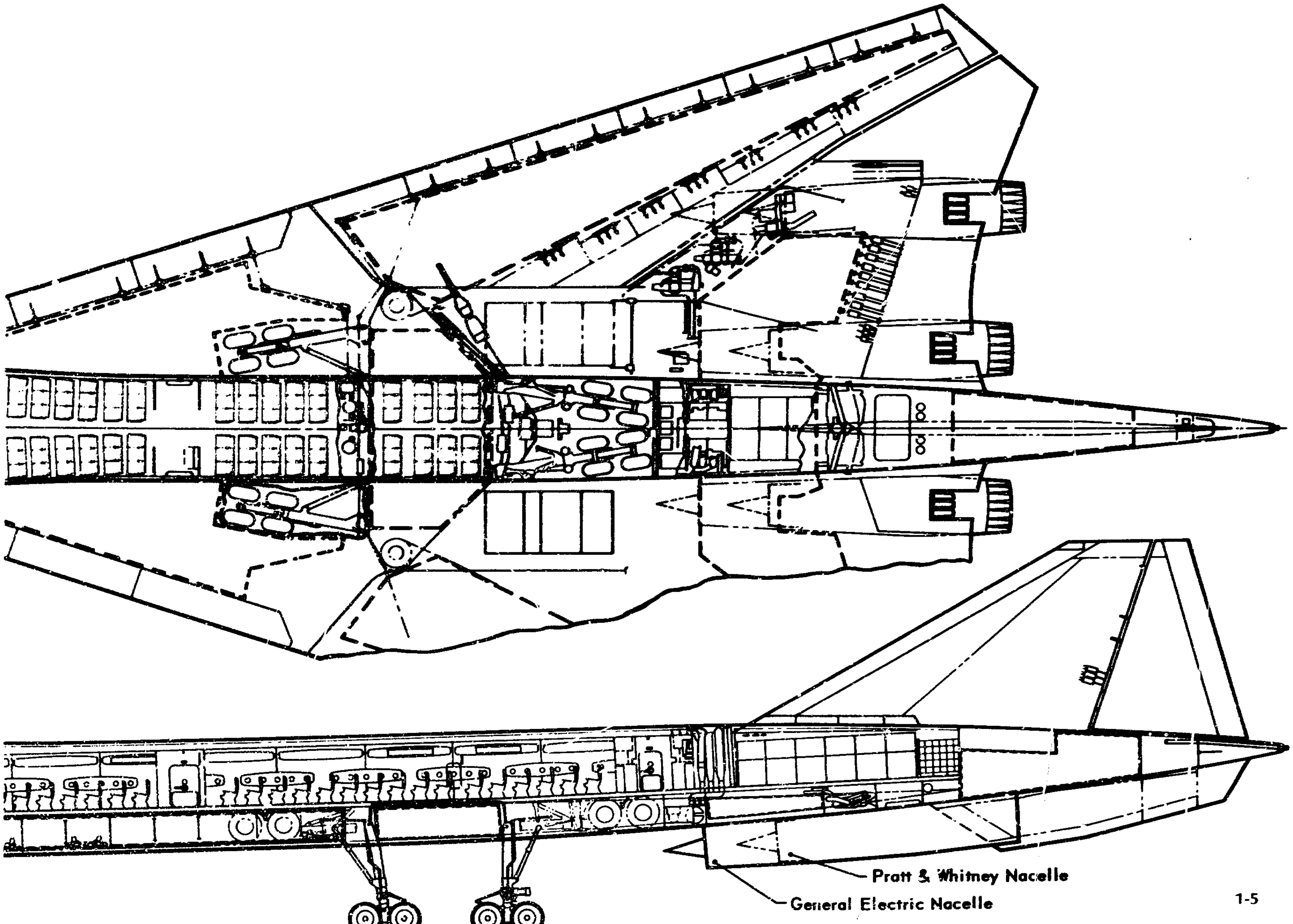

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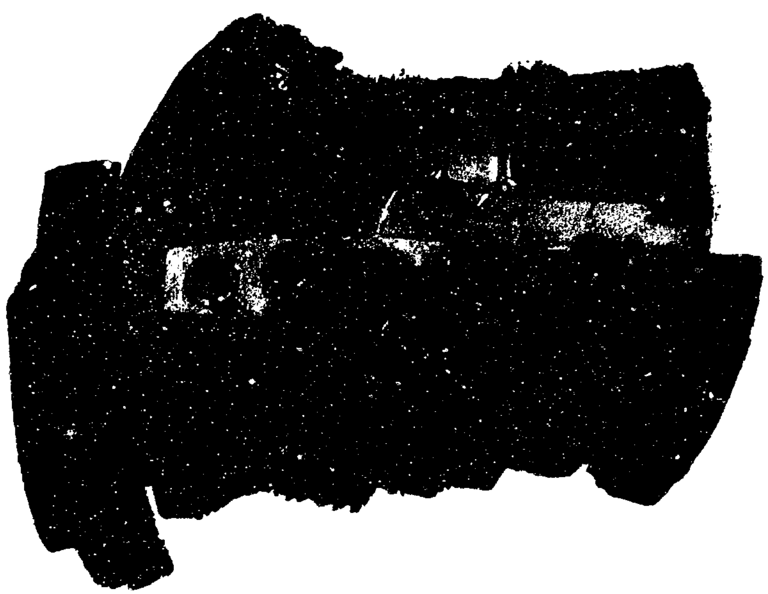
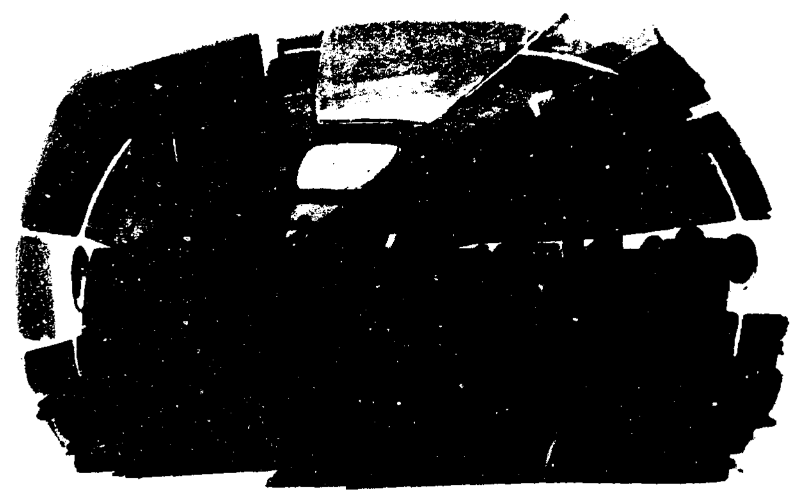
In-flight color television will inform passengers on flight crew activity "at the controls," changes of wing position, and cockpit views of takeoff and landing. Movies, travelogues, or short feature subjects will also be shown. In addition, a high-fidelity audio system with individual volume controls and headsets will cater to various musical tastes. Galleys will use the most advanced and efficient means of providing in-flight food service commensurate with the reduced flight times and the need for rapid ground servicing.





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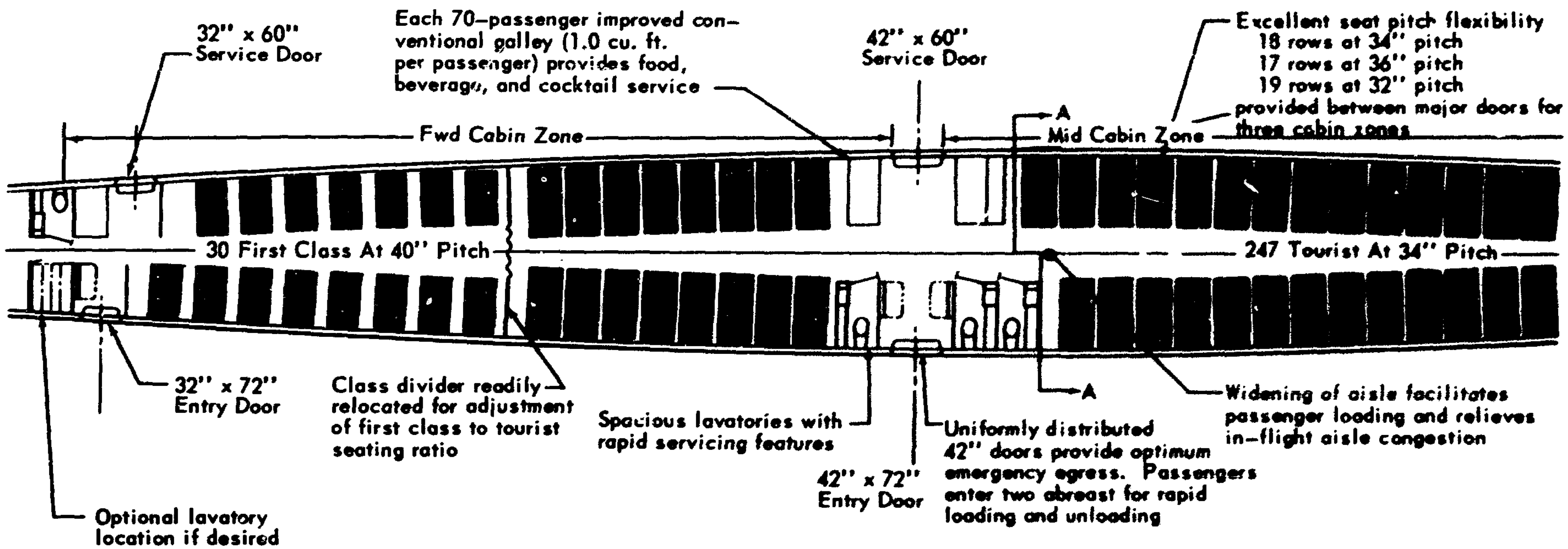
THE PASSENGER'S AIRPLANE

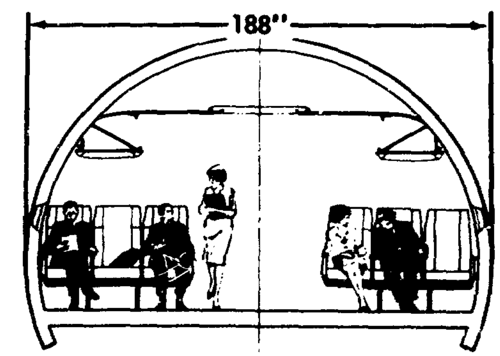
Passengers boarding the SST will find a cabin interior that is unique in appearance. Integrated shapes and forms of interior architecture; seating, overhead stowage consoles, communication consoles, lighting, and windows will be imaginative and aesthetically pleasing. There will be an efficient air conditioning and pressurization system. Noise levels will be lower than those of today's best commercial jetliners.

Seating needs have been extensively researched and as a result the SST seat will provide a new level of comfort. A thin profile, contoured seat shell with an adjustable lower back pad and headrest will conform to the passenger's proportions. Ample stowage is provided in the overhead consoles for passengers' carry-on baggage. Passenger service units suspended from the lower surface of the consoles carry reading lights, attendant call buttons, and individual fresh air outlets. The passenger service units are adjustable fore and aft for optimum position relative to seats.

V1-B2707-1

1•4 Interior Configuration





A–A

Keys to a Successful SST

What the airlines need, what the passengers prefer—Boeing knowledge of these factors has greatly influenced interior design of the B-2707.

In providing a successful SST, the following passenger cabin requirements have been fulfilled:

Maximum utilization of the airplane fuselage. Passenger, baggage, and cargo loads can be varied with fuel load to allow the airlines many range versus payload options.

Unexcelled passenger safety through design of interior materials, components, and emergency equipment. Existing Federal Air Regulations—and proposed revisions—have been complied with. The uniform distribution of wide doors and placing of attendant seats ensures safe, rapid passenger evacuation.

Improved passenger comfort through the design of increased "living space" in seats, lavatories, and doorways.

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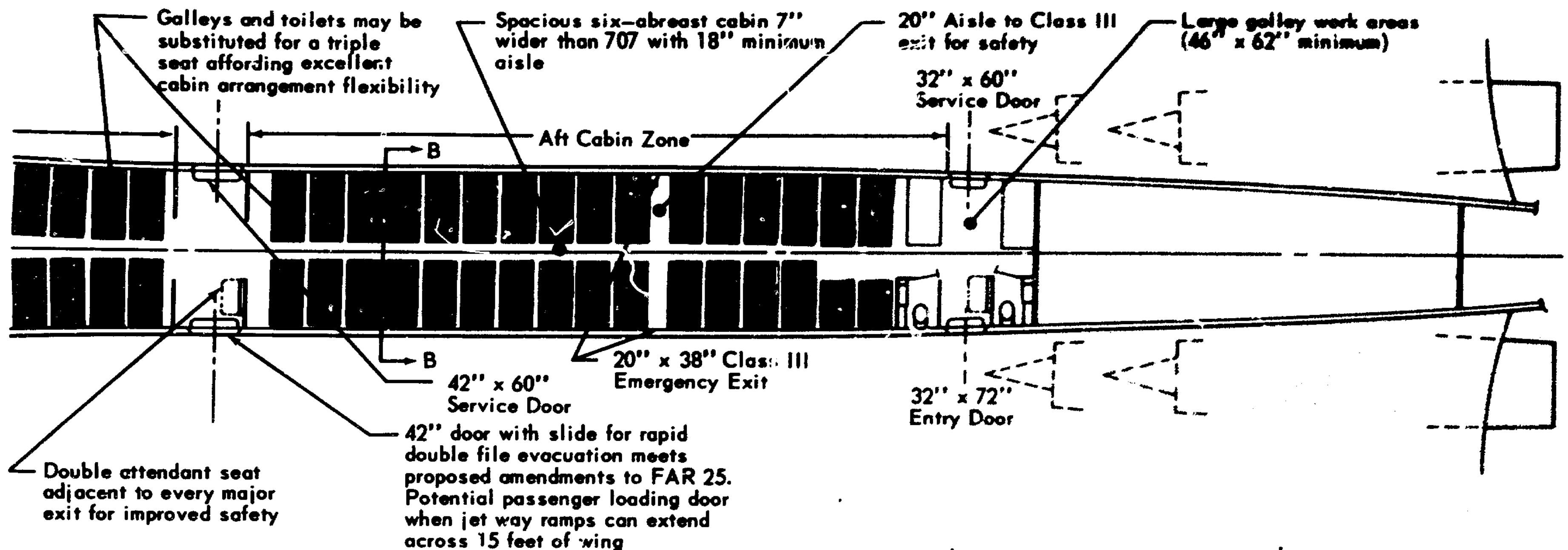


Superior interior arrangement flexibility resulting from:

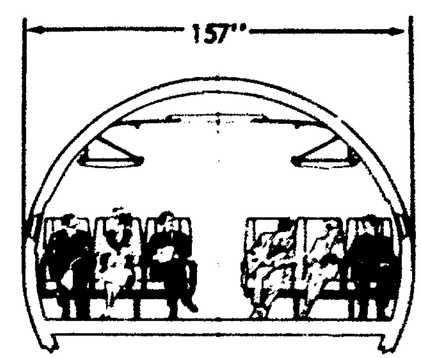
Spacious six-abreast cabin seating which permits installation of opposing galleys and toilets.

A modular design which allows for rapid substitution of seats for galleys and lavatories.

The capability to quickly adjust the ratio of first class to tourist seating by substituting seats and relocating the class divider.

Seat tracks which permit one inch increments in seat positioning.

Provisions for rapid passenger and baggage handling and for fast cabin servicing. Time sequencing and time and motion analysis have led to the optimization of door sizes and locations, aisle widths, overwing loading, and visibility.

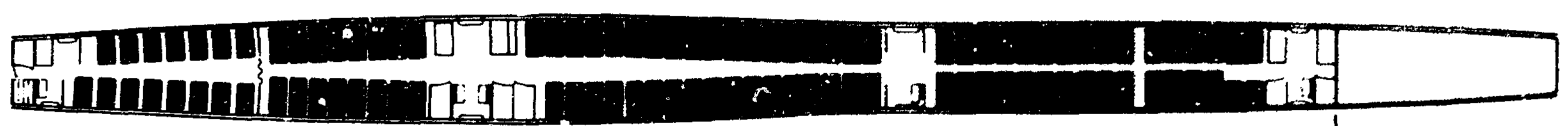


B–B

277 Passenger International Mix

V1-B2707-1

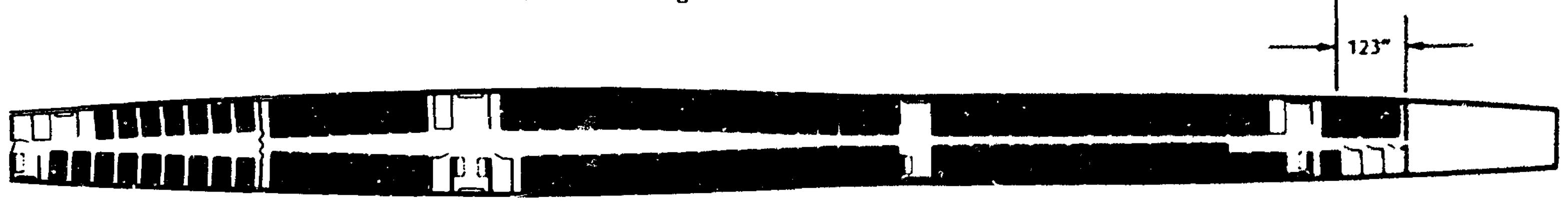
1·5 *International Configuration*



30 First Class at 40" Pitch

277 AIRLINE CONFIGURATION
Passenger International Mix

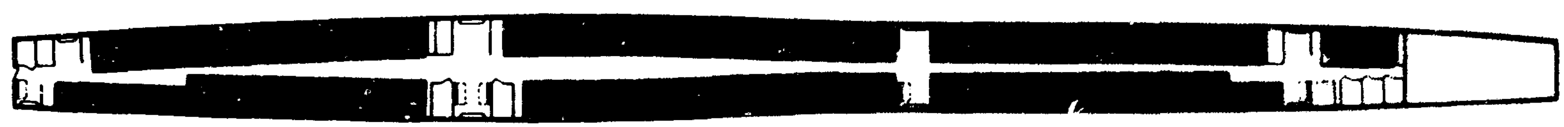
247 Tourist at 34" Pitch



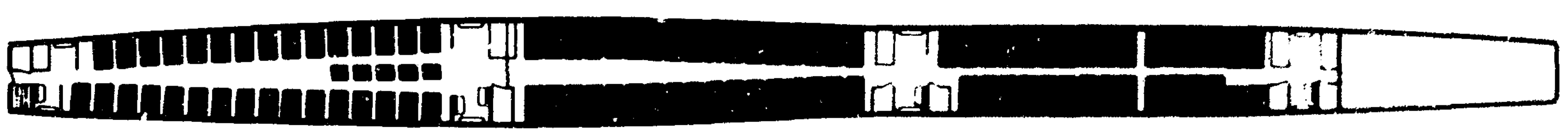
32 First Class at 40" Pitch

313 ECONOMIC CONFIGURATION
Passenger International Mix

281 Tourist at 34" Pitch



350 TOURIST CONFIGURATION
Passenger at 32" Pitch



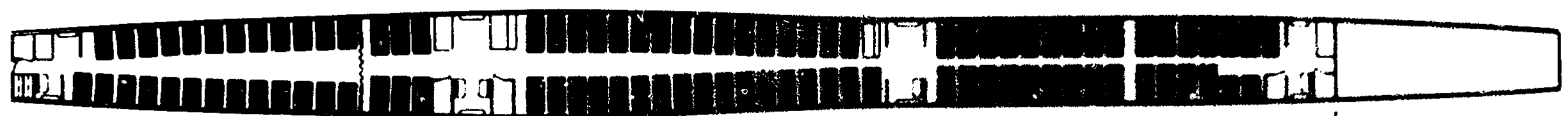
67 First Class at 40" Pitch

260 DELUXE AIRLINE CONFIGURATION
Passenger International Mix

193 Tourist at 34" Pitch

V1 87707-1

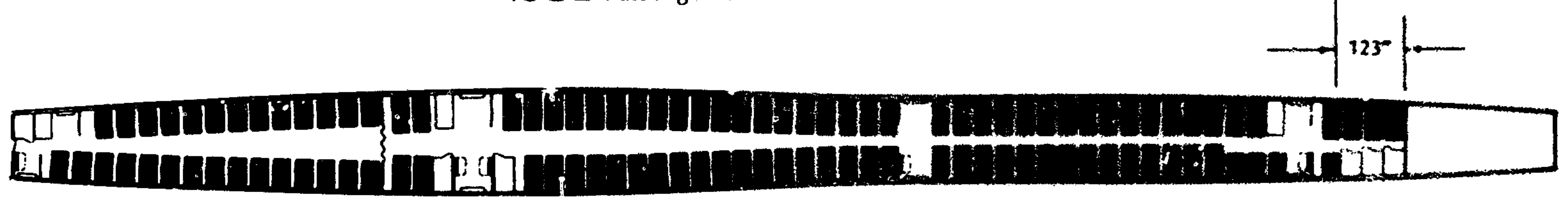
1·6 *Domestic Configuration*



50 First Class at 38" Pitch

261 AIRLINE CONFIGURATION Passenger Domestic Mix

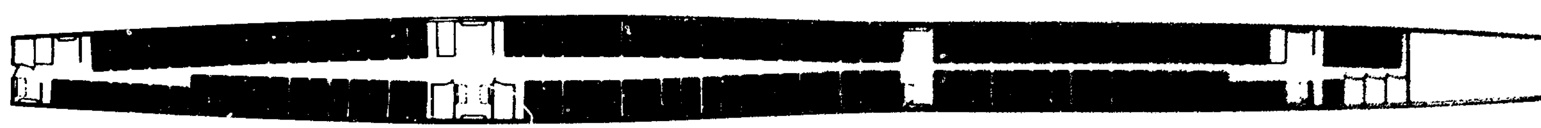
211 Tourist at 36" Pitch



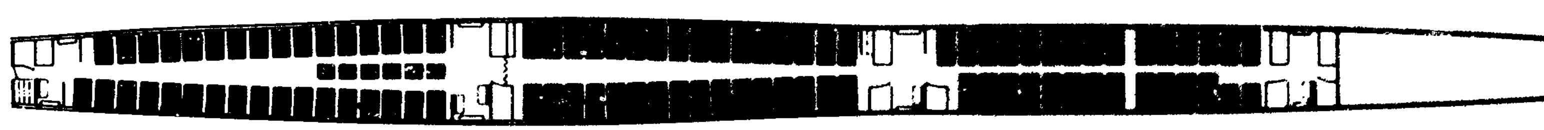
56 First Class at 38" Pitch

289 ECONOMIC CONFIGURATION Passenger Domestic Mix

233 Tourist at 36" Pitch



334 TOURIST CONFIGURATION Passenger at 34" Pitch

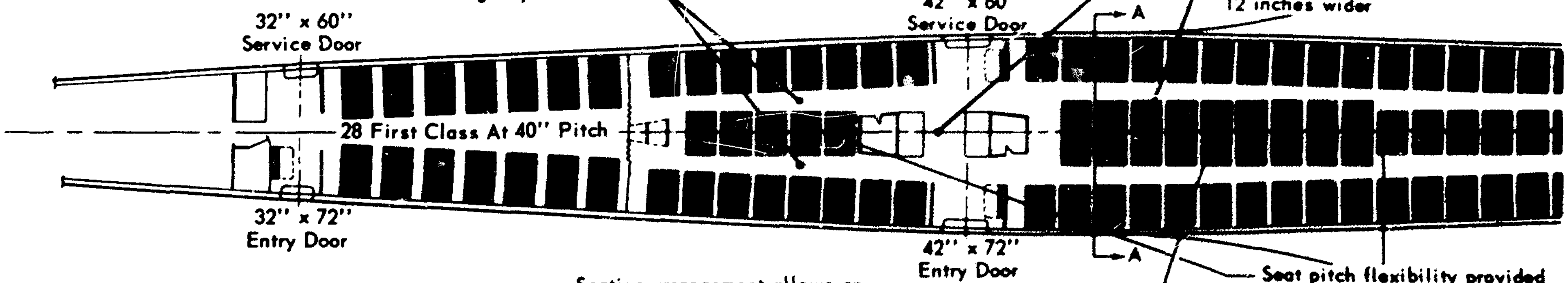


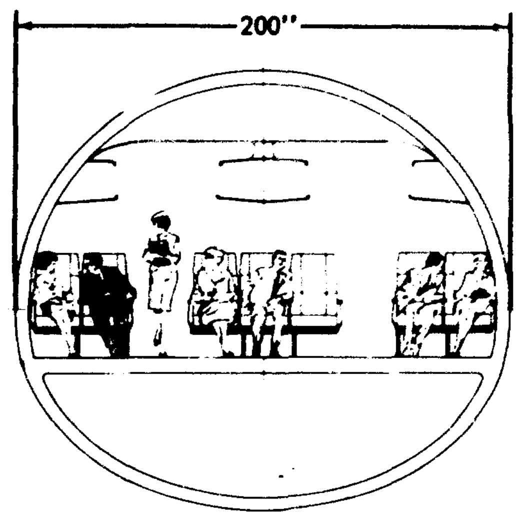
72 First Class at 38" Pitch

253 DELUXE AIRLINE CONFIGURATION Passenger Domestic Mix

181 Tourist at 36" Pitch

1•7 *Interior Arrangement*





A-A

Alternate Body Configuration

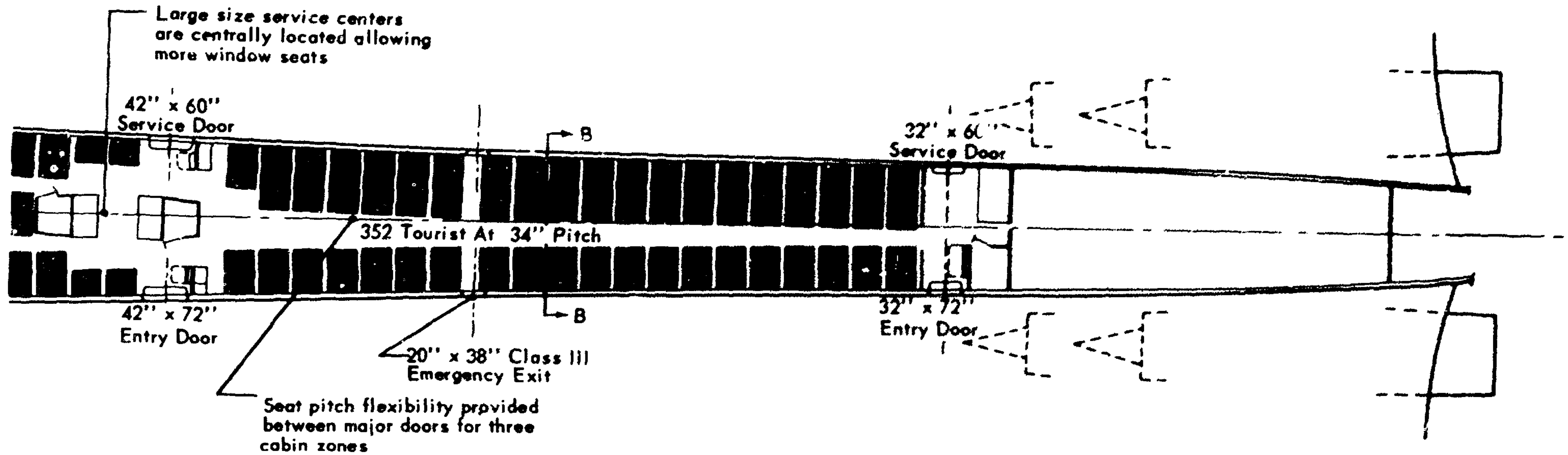
During configuration development of the B-2707, extensive design and testing pertaining to the optimum body and wing combination has continued at a rapid pace.

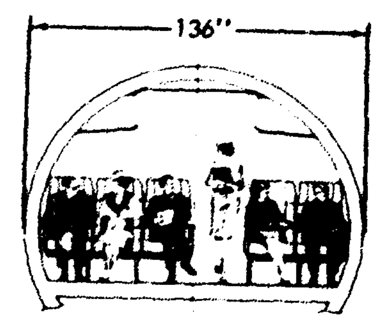
Boeing has discussed an advanced configuration with the airlines to better determine the ultimate configuration from an airline operational viewpoint.

The advanced configuration is offered as an alternate to the basic body with no change in performance, cost, or schedule.

The major features of this configuration are:

Spacious 7 abreast seating with twin aisles is achieved with a minimal increase of 12 inches in body diameter at the maximum cross-section.





B-B

More passengers with window seats because galley and lavatory service modules may be centrally located.

The two aisles provide improved evacuation safety as well as elimination of inflight aisle congestion.

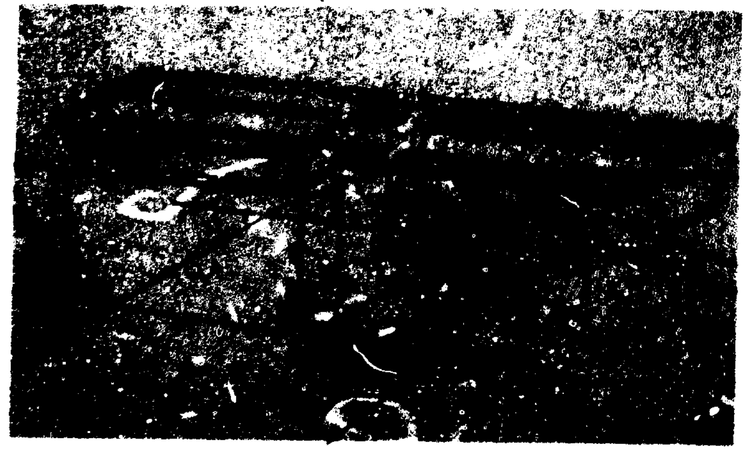
The increased use of double tourist seats provides an upgrading of passenger appeal.

The small reduction in cross-section at the rearward portion of the body and the increased cross-section in the forward portion provides a more optimum area-ruled total airplane. The combination provides the same weight and drag for the airplane with either body; therefore, all technical data presented is the same for both the basic and alternate bodies.

280 *Passenger International Mix – Alternate Body*

V1-B2707-1

1·8 *Forward Compartment*



1·9 *Aft Compartment*

BAGGAGE AND CARGO

The importance of rapid and efficient thru-stop and turnaround baggage and cargo handling has received full recognition in the design of this system for the SST.

Baggage and cargo capacity of the B-2707 exceeds the airline requirements of 5.0 cubic feet per passenger using the optional containerized system. The forward compartment is located in the lower lobe of the aircraft aft of the nose gear; the aft compartment is located behind the passenger cabin in the upper lobe.

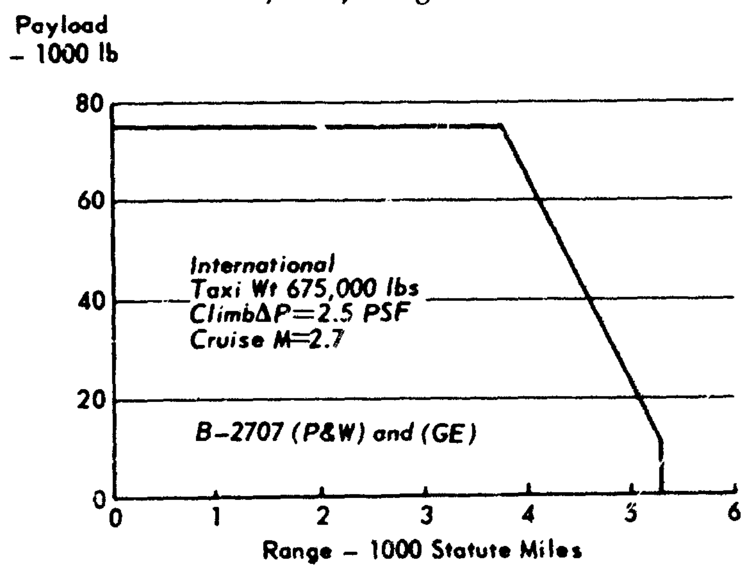
Both compartments are designed to use preloaded containers and eliminate secondary transfer of baggage at the airplane. Each compartment utilizes a self-contained hoist and lateral transfer system to provide for expeditious and simplified operation. The container size and shape is optimized for each compartment to provide the best utilization of volume available.

1·10 *Cargo Capability*

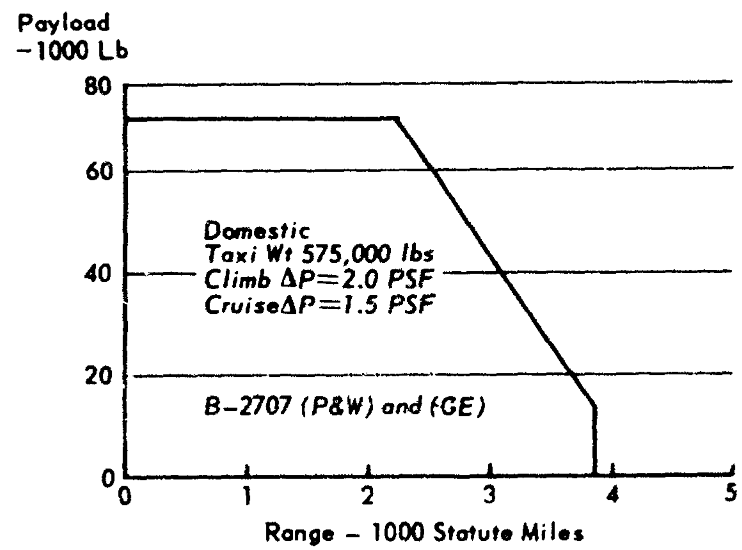
Airline Configurations		
	Bulk Load Cu. Ft.	*Container Load Cu. Ft.*
Forward-Compartment	1,902	16 At 86 Cu. Ft. 1,376
Aft.-Compartment	1,204	6 At 118 Cu. Ft. 708
		Hand Load 140
Total	3,106	2,224
Economic and Tourist Configurations		
Forward-Compartment	1,902	16 At 86 Cu. Ft. 1,376
Aft.-Compartment	611	3 At 124 Cu. Ft. 372
		Hand Load 140
Total	2,513	1,888

V1-B2707-1

1•11 *Payload/Range—International*



1•12 *Payload/Range—Domestic*



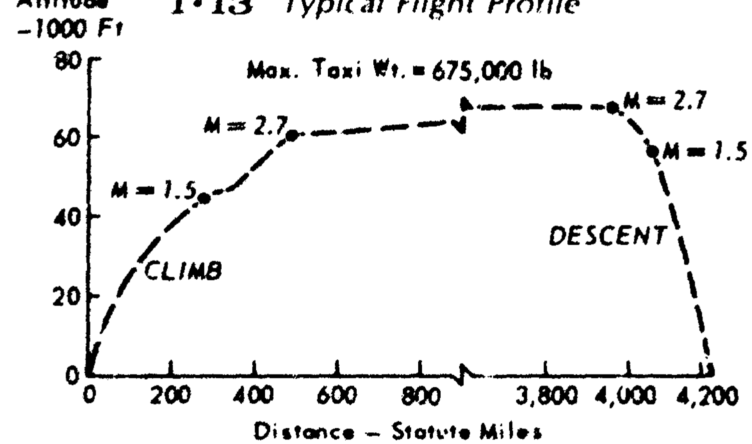
PERFORMANCE

Evolution of the Boeing Model 2707 during Phase IIC has resulted in substantially improved payload-range capability in excess of the Phase III objectives while retaining the outstanding low speed performance and low community noise levels. The major airplane characteristics are shown in Table 1-15. The B-2707 flying an international mission follows the flight profile shown in Fig. 1-13. The sonic boom overpressure during climb is 2.5 psf.

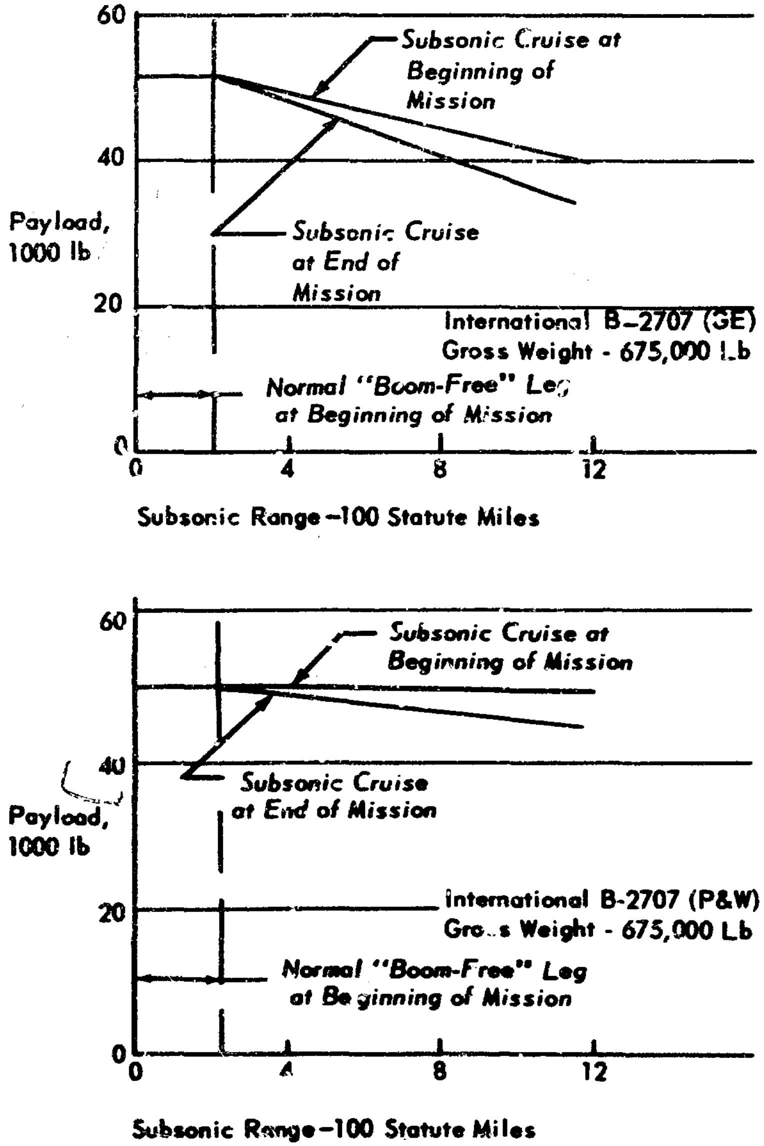
Payload-range capability of the B-2707 (Fig. 1-11) was calculated using the FAA Supersonic Transport Economic Model Ground Rules (SST 66-3) for the international missions. The B-2707 carries 277 passengers (International Mixed Seating) 4250 miles at M = 2.7 under these rules. This range exceeds FAA objectives by 250 miles. Design range selection for the B-2707 was strongly influenced by airline desires for additional range capability so that economic payloads could be carried under all temperature conditions using airline reserve and operating rules.

A domestic airplane with a maximum taxi weight of 575,000 pounds has been derived from the international version. The two airplanes are identical except that the structure has been designed for the lower gross weight. Payload-range data for domestic missions (Fig. 1-12) meet the climb and cruise overpressure objectives of 2.0 and 1.5 psi. The domestic mixed seating arrangement according to the Economic Model Ground Rules accommodates 261 passengers.

1•13 *Typical Flight Profile*



1·14 *Subsonic Cruise*



Subsonic Cruise

Subsonic cruise at the beginning or end of a flight would be required if supersonic flight is prohibited over certain areas. The B-2707 cruises efficiently at a Mach number of .85 with a wing sweep of 42 degrees.

If the flight planned does not require maximum takeoff gross weight, then small amounts of additional fuel would be required. If, however, the flight plan already requires takeoff at maximum gross weight some loss of payload may result (Fig. 1-14). The Boeing variable sweep wing and the P&W engine will cause the least possible payload loss in such instances.

Takeoff and Landing Distances

Takeoff field lengths for the B-2707 using maximum augmented thrust are substantially better than the FAA objectives for a hot day (Fig. 1-16), for either the GE- or P&W-powered international airplanes. The short takeoff distance and the excellent climbout capability of the B-2707 provide additional safety for B-2707 operation. Takeoff speed is 162 knots for the international airplane and 150 knots for the domestic.

FAR landing field lengths for either GE- or P&W-powered airplanes at maximum landing weight are less than 6,500 feet on a wet runway (Fig. 1-16). The B-2707 jet transport's approach speeds can be altered as a function of flap position and noise abatement requirements.

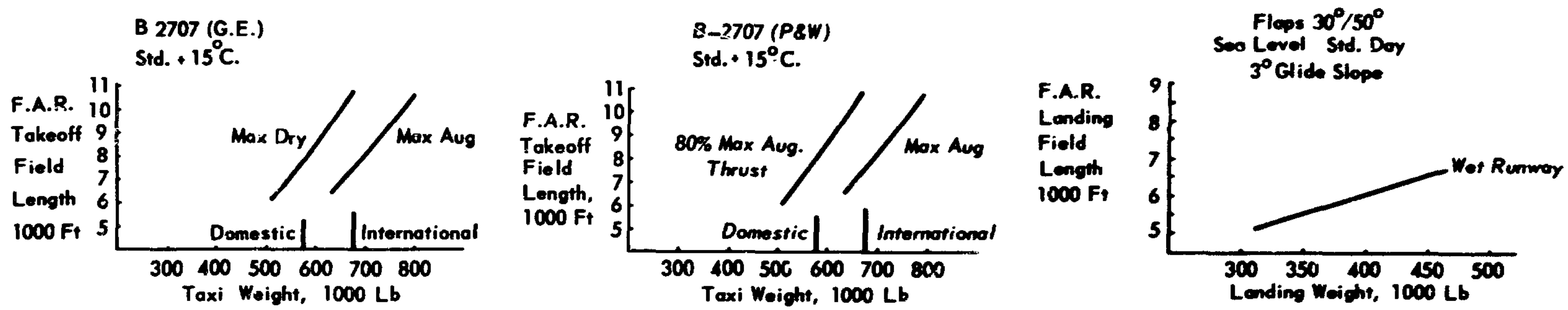
V1-B2707-1

1•15 *Airplane Characteristics*

		SUBSONIC		SUPERSONIC				
	CHARACTERISTIC	707-320B	747	B-2707(GE) Domestic	B-2707(P&WA) Domestic	B-2707(GE) Internat'l	B-2707(P&WA) Internat'l	FAA Objective Internat'l
CONFIGURATION	Gross Weight—Lb	328,000	683,000	575,000	575,000	675,000	675,000	.....
	Operating Empty Wt—Lb	140,000	339,000	275,000	273,760	287,500	285,760	.....
	Fuel Capacity—Lb	159,830	326,850	367,100	367,100	367,100	367,100	.....
	Passengers	161	461	289 **	289 **	313	313	.....
	Length—Ft	153	232	306	306	306	306	.....
	Wing Span—Ft (Low Speed)	146	196	174	174	174	174	.....
	Wing Span—Ft (High Speed)	146	196	106	106	106	106	.....
	Wing Area—Sq Ft	3,130	5,500	9,000	9,000	9,000	9,000	.....
PERFORMANCE	Takeoff							
	Liftoff Speed—Knots	168	163	149	149	162	162	.....
	F.A.R. Field Length (86°F) Ft	11,000	10,200	7,800	8,000	7,400	7,600	10,500
	Community Noise—PNdb	122	NA	92	102	95	104	105
	Sonic Boom (Climb)—PSF	.....	.....	2.0	2.0	2.5	2.5	2.5
	Cruise							
	Payload—Lb	32,200	95,350	57,800 **	57,800 **	62,600	62,600	.....
	Range—Statute Miles	6,050	5,040	2,620	2,670	4,080	4,070	4,000
	Altitude (Ave)—Ft	35,000	35,000	69,000	69,000	64,000	64,000	.....
	Speed (Long Range)—Mach	.81	.85	2.70	2.70	2.70	2.70	2.70
	Speed (Long Range)—MPH	537	565	1,780	1,780	1,780	1,780	.....
	Sonic Boom—PSF	.....	.....	1.5	1.5	1.9 to 1.4	1.9 to 1.4	1.7
	Landing (Max Weight)							
	Approach Speed—Knots	126	130	129	127	132	131	.....
	Community Noise—PNdb	124	NA	98 *	111 *	98 *	111 *	109
	F.A.R. Field Length Wet—Ft	6,850	6,830	6,200	6,100	6,500	6,400	8,000
OPERATIONS	Runway Thickness							
	Rigid—Inches	12	11	11	11	12	12	.....
	Flexible—Inches	24	21	21	21	24	24	.....
	Thru-Flight Service—Min	30	30	20	20	20	20	30
	Turnaround Time—Min	60	60	30	30	30	30	90

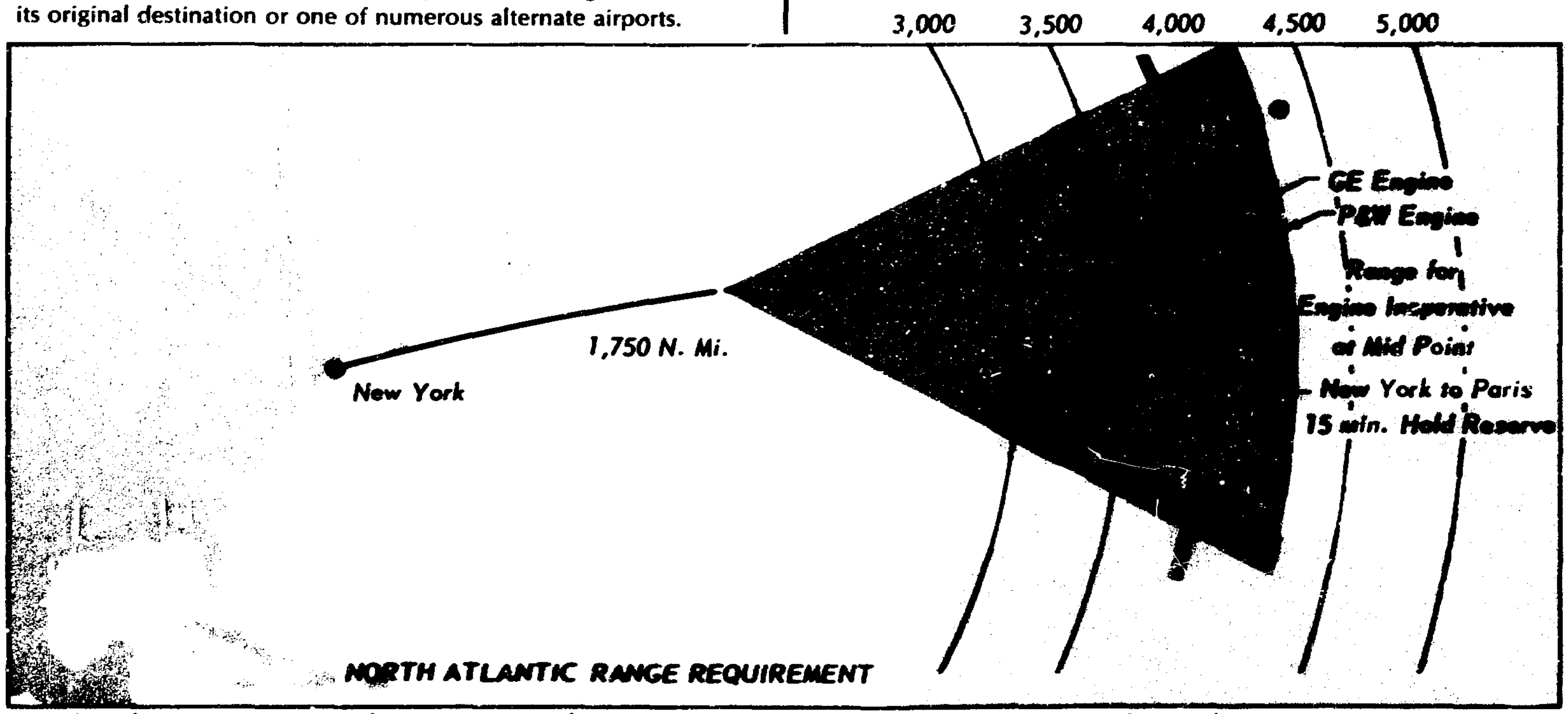
*Decelerating Approach **See Growth Document For Alternates

1•16 *F.A.R. Field Length*



Midflight Engine Failure

In the event that an engine fails midway between New York and Paris, the B-2707 has a sufficient range on three engines to reach its original destination or one of numerous alternate airports.



1•17 *Three Engine Performance Mid-New York-Paris (B-2707 International Airplane)*

V1-B2707-1

Sonic Boom

Sonic boom predictions are based on extensive analyses of the B-2707 configuration using techniques substantiated by B-58 and B-70 test data. The predicted overpressures are summarized in Fig. for a typical international flight (New York to Paris).

The maximum overpressure of 2.5 psf satisfies the FAA objective. This maximum overpressure occurs approximately 200 miles outbound.

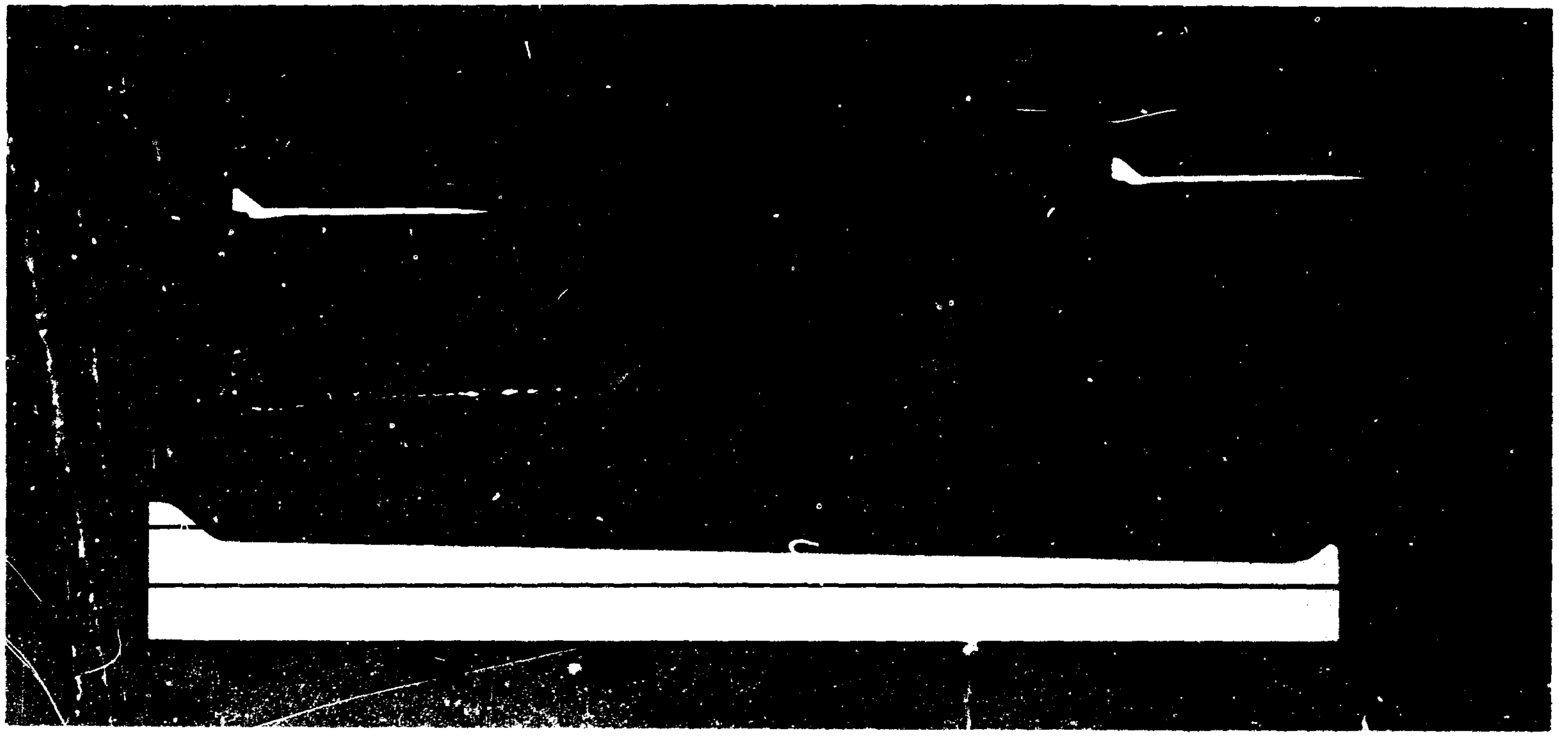
During the cruise phase, the overpressure reduces to levels well below 2 psf because of decreasing weight and increasing altitude.

The overpressure zone follows the airplane much the same as a ship's wake. When the pressure wave contacts the surface, it trails 27 miles behind the airplane, is 1100 feet long, and extends laterally 30 miles on each side of the surface track.

Upon approaching the coast of France, the airplane slows to subsonic flight and the sonic boom terminates.

The domestic B-2707 can be operated at sonic overpressures less than those shown in Fig. 0-00 because of reduced gross weight (575,000 pounds). Maximum overpressure will be limited to 2.0 psf in climb and 1.5 psf or less in cruise.

1•18 *Sonic Boom—New York to Paris*



Economics

ECONOMICS AND MARKET DEMAND

The Boeing supersonic transport design offers the airlines an assured opportunity for continued economic growth. In all respects the B-2707 is keeping pace with demands for improved air transportation. Responsiveness to the needs of the airline industry is clearly evident in the high lift wings and wide spacious interiors of both the B-747 and Boeing SST. The air traveler will continue to benefit in safety, comfort and cost as long as the market is served with designs that provide adaptability to the environment and flexibility for improving the characteristics that affect the passenger, the airline, and the community.

For economy, the Boeing supersonic transport offers:

- Low Operating Cost . . . per seat mile
- Good Profit Potential . . . consistent with market adaptability
- Maximum Return for Value . . . to passengers, airlines, manufacturer and Government
- High Passenger Appeal . . . for high load factor
- Growth . . . for market adaptability.

At present airlines use such efficient and productive vehicles as the Boeing 707 and 727 and the Douglas jet transports. But in the near future world markets will respond to the large subsonic and supersonic jet transports. These aircraft will be more productive and more specifically market oriented than current jets. The impact of large subsonic and supersonic jets on marketability and economics is shown in Fig. 2-1. When compared with the largest subsonic airplanes, the B-2707 offers three times the speed and two-thirds the number of seats for about twice the price.

	Contemporary Jet Transport			
	Subsonic		Supersonic	
	707	747	[redacted]	Concorde
Cruise Speed Mach No.	.84	.90		2.2
MPH	550	600		1450
Number Of Seats (Typical)	139–161	382–461		120–130
Gross Weight	328,000	683,000		340,000
Price (1967 Dollars)	7 1/4	18 1/2		16
Average Trip Time 2000 St. Miles	4:00	3:45		2:05

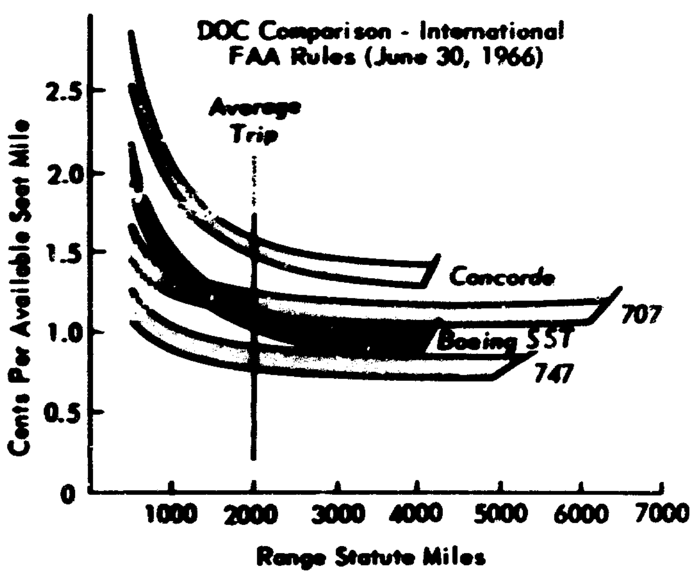
2·1 *Comparison of subsonic and supersonic transports indicates that the B-2707 flies 3 times as fast for 2 times the price.*

DIRECT OPERATING COST

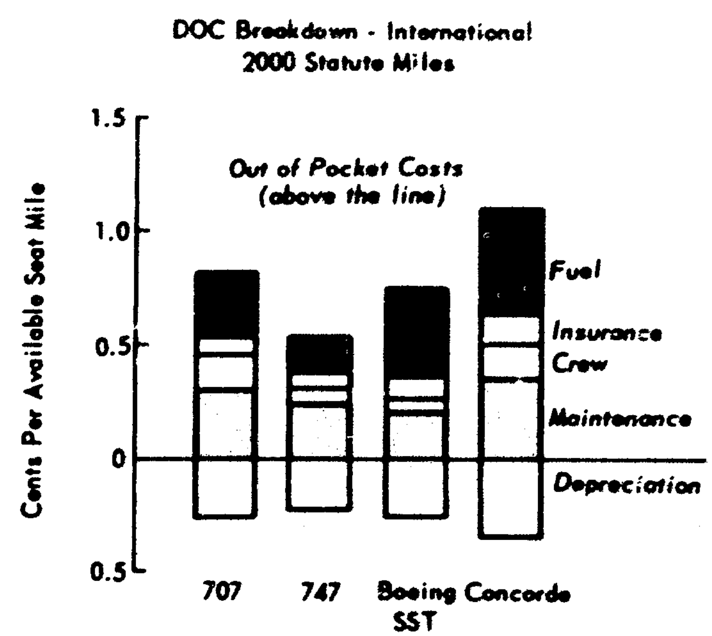
The economic efficiency of an airplane can be illustrated in many ways. Probably the most basic method is the relationship of direct operating costs in cents per available seat mile. This is, in a sense, a measure of achievement in obtaining the highest speed for the least fuel and of carrying the most passengers while fulfilling airline requirements for practical operation.

B-2707 DOC will be the same as or lower than subsonic costs per seat in all accounts except fuel under FAA economic rules. This relationship, and the impact of passenger capacity in achieving lower operating unit costs, are shown in Fig. 2-3.

For an international operation under FAA Phase II-C rules, Boeing SST operating costs per seat are well below those of subsonic jets and of the Concorde. In fact, they are only slightly higher than the operating costs of proposed subsonic transports (Fig. 2-2) of larger passenger capacity.



2·2 *B-2707's direct operating cost (DOC) competes effectively with subsonic jets at medium to long ranges.*



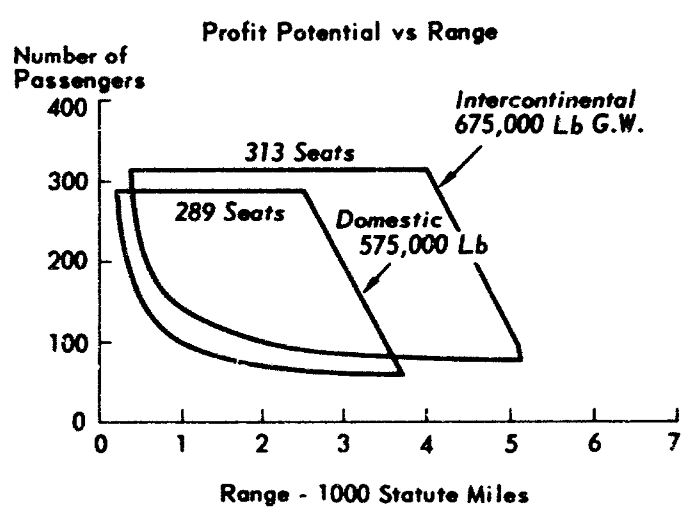
2·3 *Boeing Model B-2707 is compatible with subsonic jet costs in all categories except fuel.*

PRODUCTIVITY

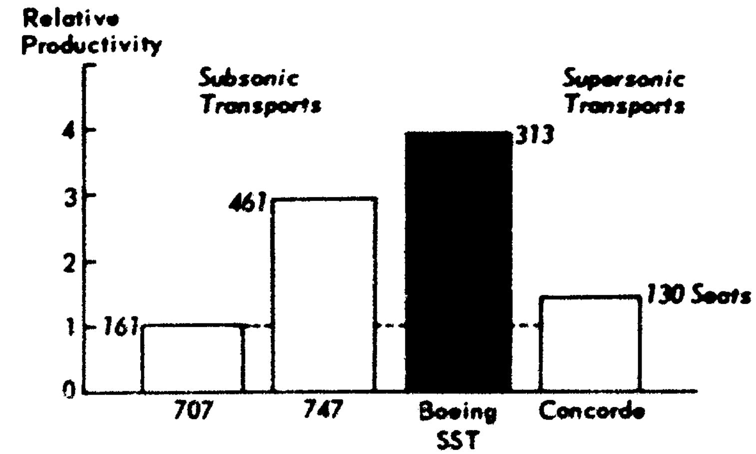
B-2707 productivity—work capacity—in available seat miles per year for an average 2000-statute-mile range is shown in Fig. 2-4. B-2707 productivity is equivalent to that of almost four 707's or three Concordes, and is still 30 percent better than the large capacity subsonic jets. Airplane productivity is a function of speed and capacity. In practical airline systems, variations in seating combinations, trip time, and utilization may be required for individual markets. The increase in passenger cabin size (implemented in the B-747 and planned in the Boeing SST) and the high lift variable sweep wing are designed to increase adaptability and productivity in matching specific airline markets.

PROFIT POTENTIAL

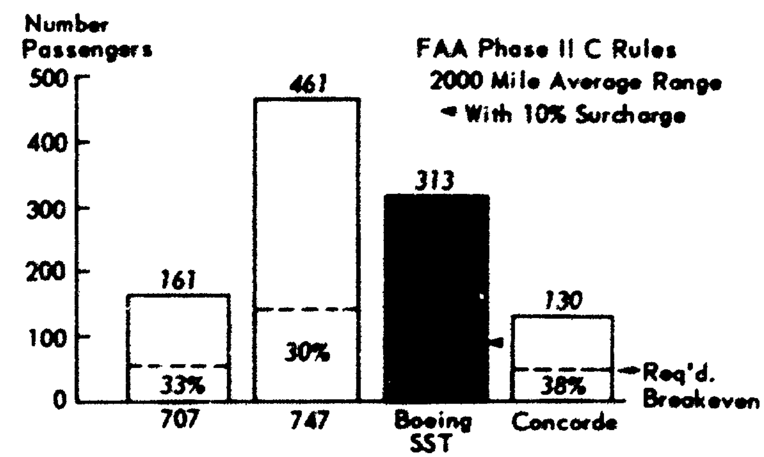
The Boeing SST's capability for earning profits similar to those of large subsonic transports appears promising considering the impact of passenger appeal in attaining high load factors. Profit potential when operating under FAA Phase II-C rules is shown in Figs. 2-5 and 2-6. Breakeven load factors are approximately 25 to 30 percent at average ranges of approximately 2000 statute miles.



2-1 *B-2707 offers inviting profit potential over a wide range of trip lengths.*



2-5 *Productivity of the Boeing SST is four times greater than the B-707 and 30 percent greater than the B-747 – because of the SST's greater speed.*



2-6 *The Boeing SST operates at a breakeven percentage equivalent to current subsonic jets and offers a greater earning capacity.*

INVESTMENT

The Boeing SST requires an investment per unit of productivity from 25 to 50 percent greater, at average ranges, than for large subsonic jets (Fig. 2-7).

The speed of the B-2707 plus the additional passenger appeal of stable flight characteristics and spacious interiors should more than justify the higher investment.

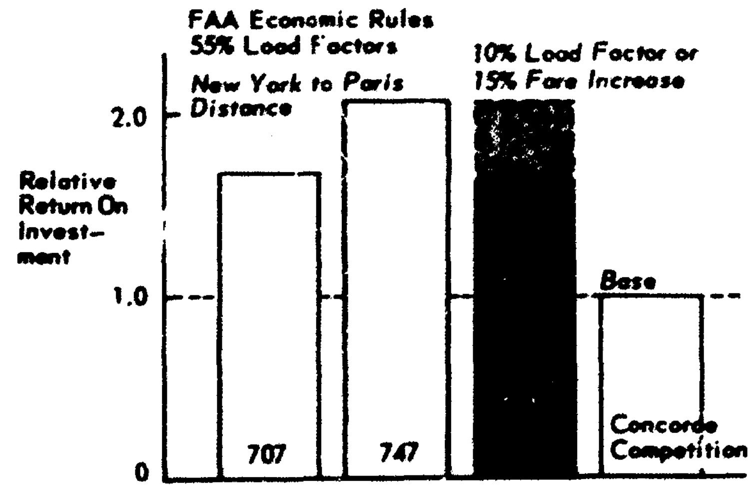
The B-2707 provides the potential for a return on investment (ROI) equal to that of current subsonic jets, and only 22 percent lower than the ROI of large subsonic jets at the same load factor and fare (Fig. 2-8). Allowing a 10 percent increase in load factor or a 15 percent increase in the fare would yield the same ROI for the supersonic transport as for the large subsonic jet.

Unit Investment

	Subsonic		Supersonic	
At 2000 Miles (Ave. Trip)	707	747	[redacted]	Concorde
Airplane Price (Millions)	7¼	18½	[redacted]	16
Utilization (Hrs/Yr) *	3300	3300	[redacted]	3000
Number Of Seats	161	461	[redacted]	130
Useful Life*	12	12	[redacted]	15
Block Speed	495	508	[redacted]	952
Investment Per Available Seat Mile ...	.23¢	.20¢	[redacted]	.29¢
		@12 Yrs	[redacted]	.36¢

***FAA Phase IIC Rules**

2·7 *Comparison of investment required per unit of productivity.*



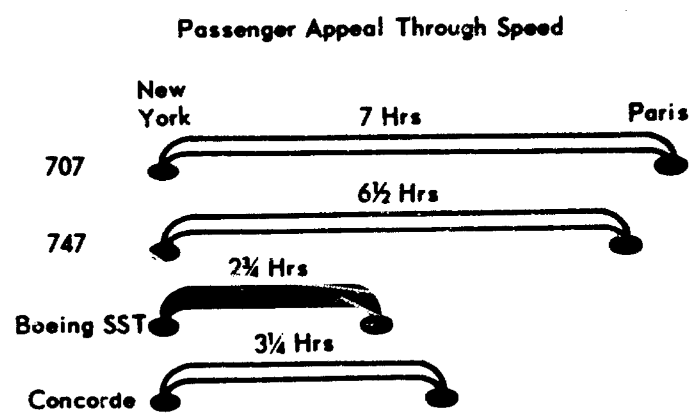
2·8 *A small increase in load factor or a differential in fare structure would enable the B-2707 to compete favorably with future subsonic jets for return on investment.*

V1-B2707-1

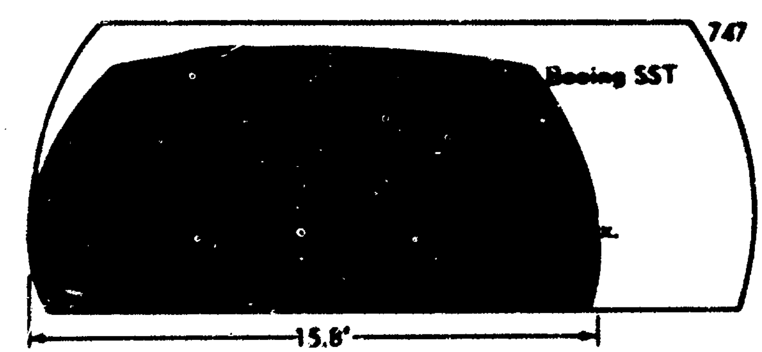
PASSENGER APPEAL

Passenger appeal is a major determinant in a successful SST program for the manufacturer, the airline, and the government. The SST's speed will provide this appeal. Figure 2-9 illustrates how more than four hours of travel time is saved on a trip from New York to Paris.

Besides its speed, the Boeing supersonic transport offers the air traveler reliability, low cost, and a stable, quiet ride in a modern, spacious interior commensurate with the 1970-80 time period. On entering the Boeing SST travelers will pass through 42-inch wide doors into a large cabin with multiple or 4-foot wide aisles. Cabins are up to 30 percent wider and offer 80 percent more volume than current subsonic jets. The Boeing SST interior allows free passenger movement throughout. Figure 2-10 illustrates the impact of the wide-room concept of the Boeing SST and the Boeing 747, in relation to the conventional aircraft interiors of today.



2-9 *The Boeing SST offers passengers 3 times the speed to cut travel time from New York to Europe in half.*



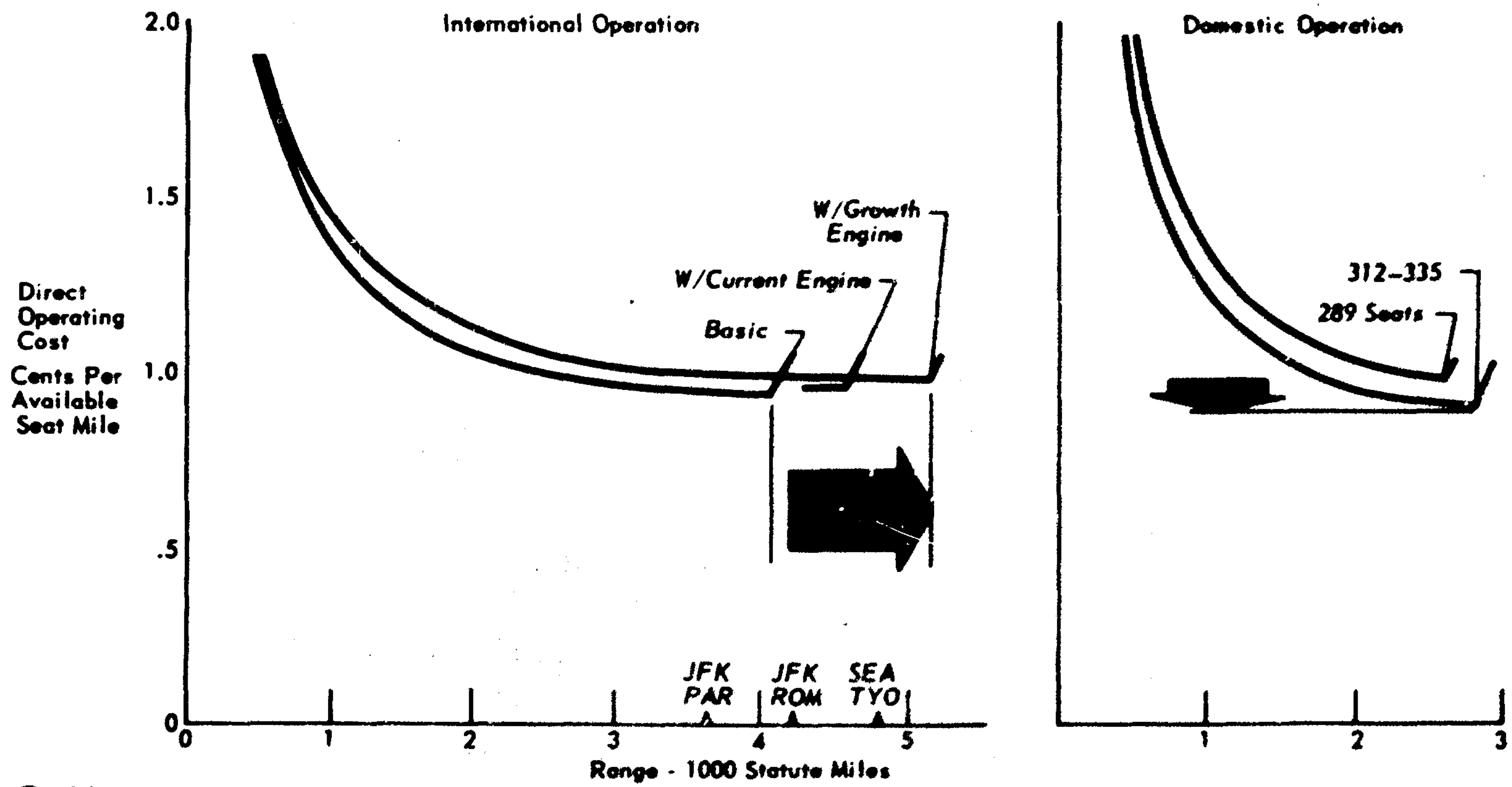
2-10 *Boeing's concept for airplane interiors has moved up from the wide cabin to a wide-room design. The B-2707 interior offers multiple or wide aisles, double-width entry doors, wide seats, and less congestion.*

GROWTH

Flexibility is fundamental in the design of the B-2707—flexibility in supersonic-to-subsonic operations for sonic boom restraint, flexibility in adapting to low speed operations for traffic and terminal environments, and flexibility for growth in size and range performance.

Improvements in structural and aerodynamic efficiency as well as increased engine thrust and fuel economy can be expected from extensive testing of structures, wind tunnel models and the prototype. Airframe and engine improvements are foreseen two to five years after introduction as shown in Fig. 2-11. International operators will take advantage of growth to increase range and payload on such routes as New York to Rome and Seattle to Tokyo. Domestic operators will use improved engines to achieve lower unit operating costs through increased seating capacity.

Boeing SST growth capability will have a powerful economic impact on the dynamic air travel market. Supersonic speeds will open new markets, but the depth of penetration will depend largely upon the adaptability of the design for growth in developing lower unit operating cost. Sizing of the Boeing SST reflects a keen awareness of airline market considerations.



2•11 *Improved technology forecast for the next few years can be expected to increase range and reduce costs.*

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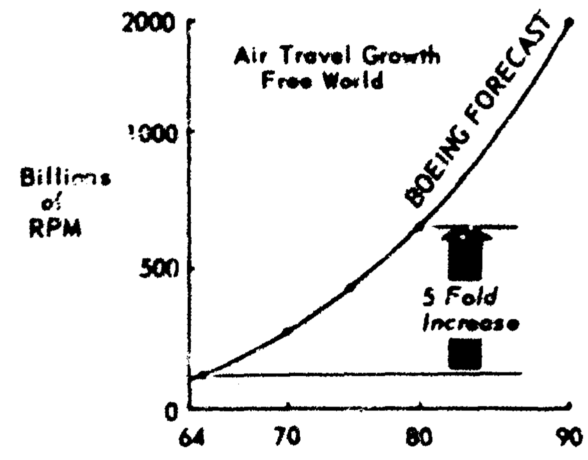
MARKET

Boeing forecasts indicate that free world air travel is entering a period of growth that will dwarf that of the past few years (Fig. 2-12). Between 1965 and 1980 free world Revenue Passenger Miles are predicted to increase five times (10 times by 1990).

The high productivity of the B-2707—with its growth versions—is ideally suited to the increasing demands and peak load requirements. Greater seat-mile capacity helps to reduce airport congestion and new facility requirements. Passenger handling will not be a problem since airports will have accommodated the Boeing 747 for at least four years.

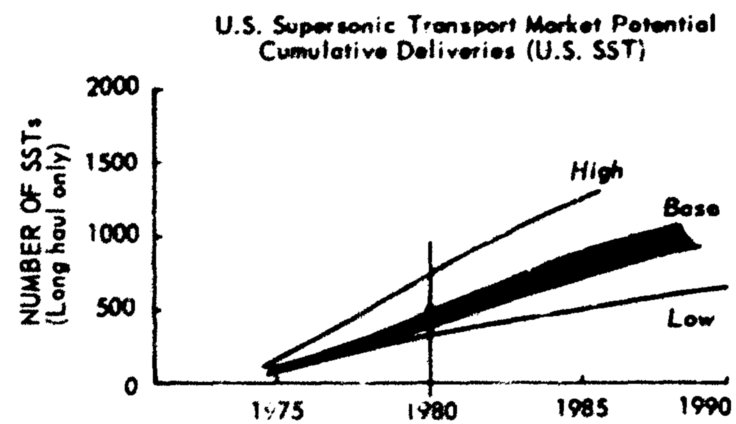


2 • 12 *Size of the B-2707 is consistent with the dynamic and growing market.*

Boeing analyses show that the SST market can be very large. The range of outcomes over time is shown in Fig. 2-13. Even in 1980 a substantial market exists:

Low Level	315 airplanes
High Level	750 airplanes
Base Level	390-475 airplanes

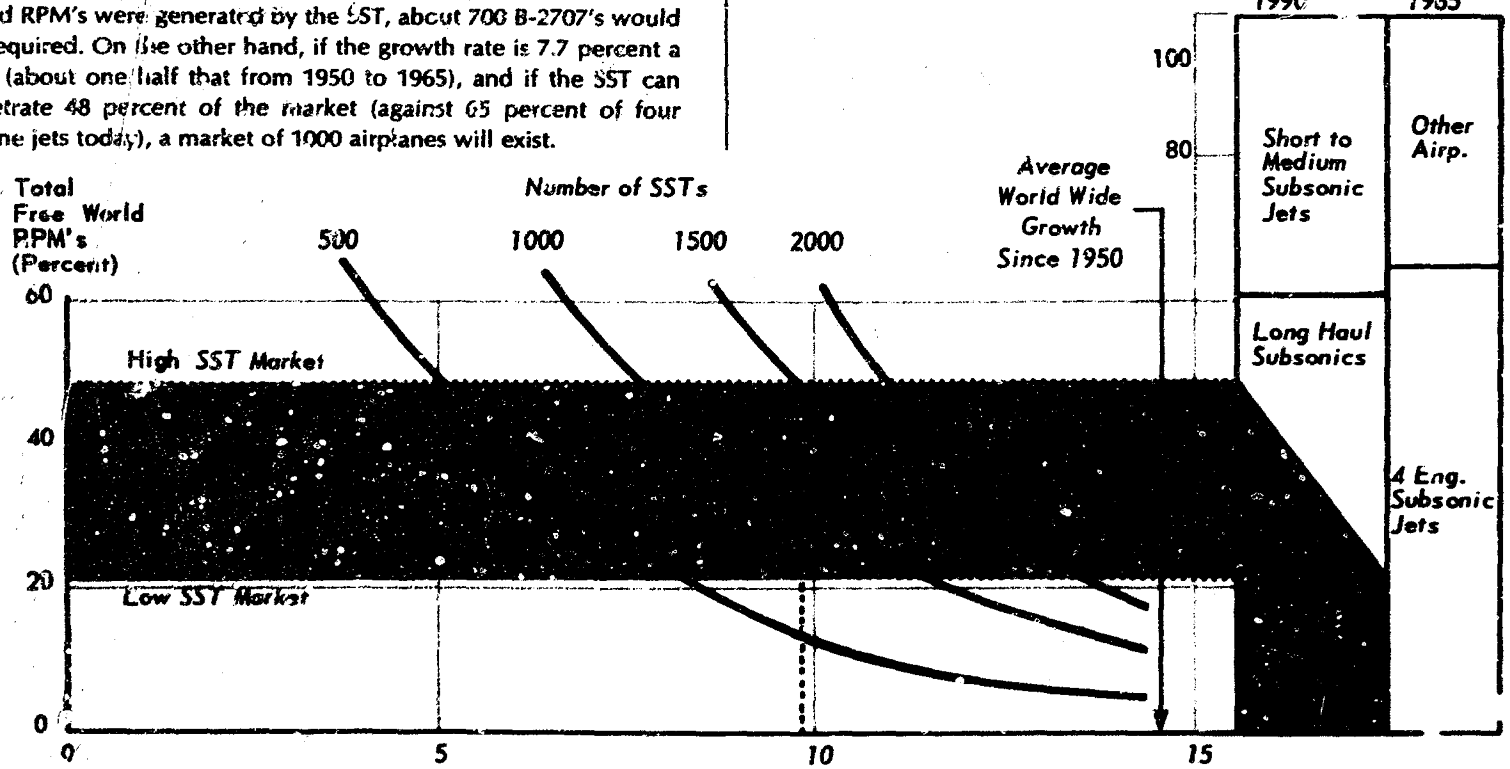
The B-2707, with its superior passenger appeal and optimized low and high speed configurations, is likely to achieve market penetration equal to or above these levels.



2 • 13 *SSTs required in the 1975-1990 time period indicate a large market potential exists for airplanes even in the early years of the program.*

Looking toward the 1990 program potential, Boeing analyses show that the SST market in 1990 can be very large—even when such factors as sonic boom operational restrictions, possible total traffic volume variations, and various speed/fare preference assumptions are considered. Figure 2-14 shows the relationship between SST percent of total free world Revenue Passenger Miles in 1990, the average free world traffic growth, and the number of SST's required. The probable range of outcomes is shown by the shaded band. If, at the expected growth rate, only 20 percent of the free world RPM's were generated by the SST, about 700 B-2707's would be required. On the other hand, if the growth rate is 7.7 percent a year (about one half that from 1950 to 1965), and if the SST can penetrate 48 percent of the market (against 65 percent of four engine jets today), a market of 1000 airplanes will exist.

SUPERSONIC MARKET POTENTIAL MATRIX.....TO 1990



2·14 *Boeing base forecasts of the most likely SST market are based on an average growth rate of 9.75 percent and indicate a requirement for 1100 SST's. This amounts to only 35 percent of the total free world market in 1990 compared to 65 percent of the market served today by four-engine long-haul subsonic jets.*

Operational Characteristics

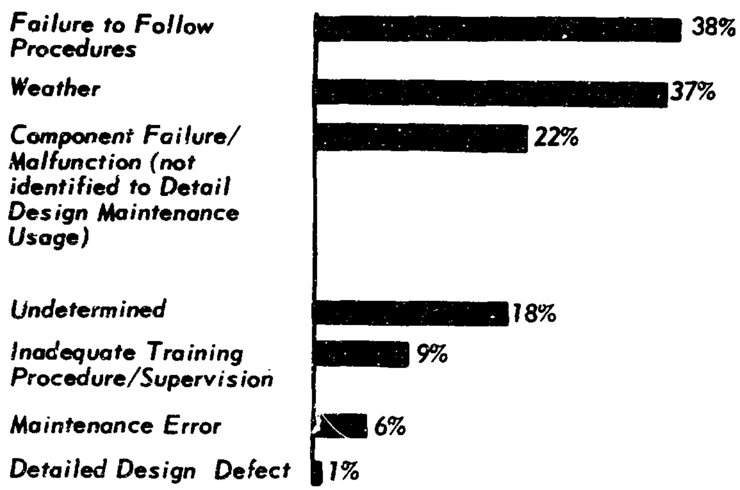
SST FLIGHT SAFETY

Elimination of all fatal accidents is a major objective of the B-2707 program. Analysis of accident and incident data indicates the pilot is the key element in flight safety. The pilot makes the final decisions, executes the critical maneuvers, and must detect, analyze, and cope with the mistakes of support organizations and equipment malfunctions.

3•1 *Free World Scheduled Airline Flight Safety*

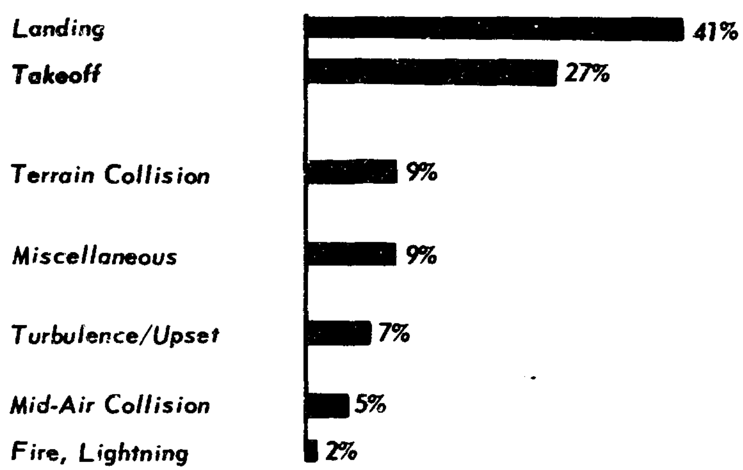
FREE WORLD SCHEDULED AIRLINE FLIGHT SAFETY

Accident Contributing Cause Factors*



* (1) *Totals over 100% – Multiple Cause Factors*
(2) *Boeing Data*

Resulting Accidents (One or More Fatalities)



Mechanical failures cause few flight accidents but are one of multiple contributing causes. The effect of these failures can be eliminated by adequate design, incorporation of fail-safe concepts, and necessary system redundancy. Planned SST inspection and maintenance procedures will provide the necessary level of maintenance for achieving airplane mechanical safety.

Landing accidents and incidents are the most critical flight safety problem, and the pilot is the most critical safety element. Pilot decisions (intuitive and objective) are biased by past experience, habit patterns, and individual limitations. The B-2707's approach and landing characteristics are important design factors affecting landing accidents, and therefore must be integrated with airline pilots' capability.

AIRLINE SAFETY TRENDS

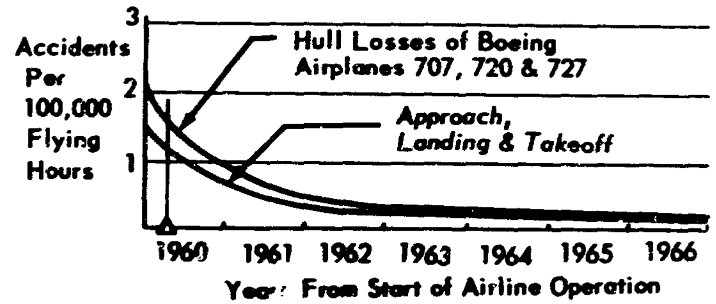
The accident rate for all Boeing commercial transports is low and decreasing.

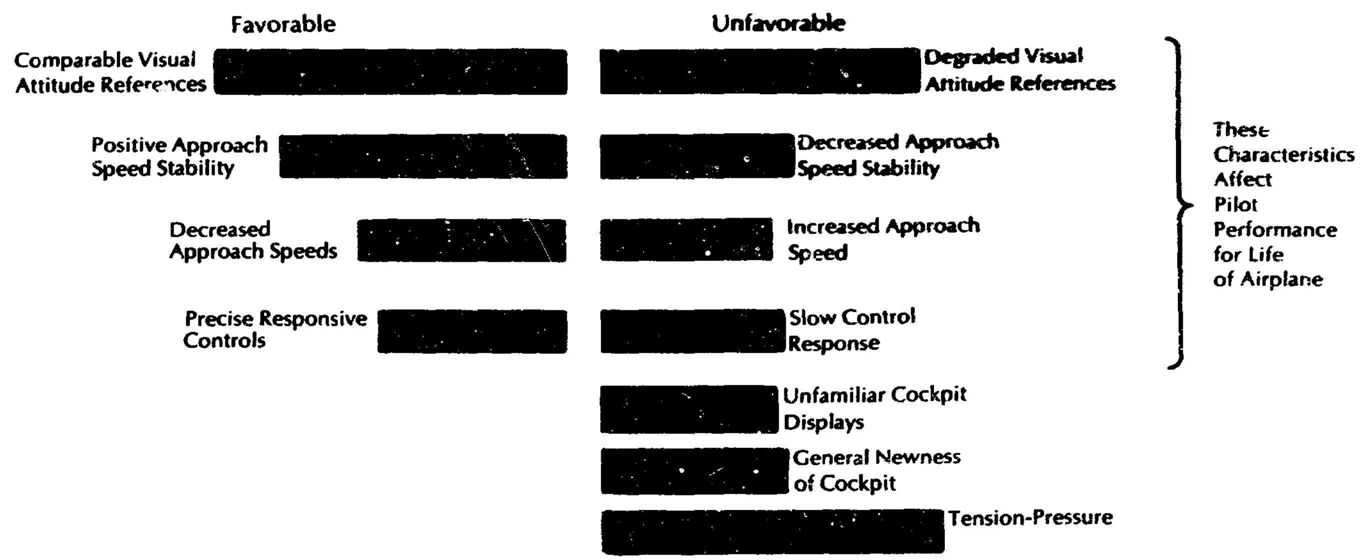
Landing and approach accidents are most frequent; next most frequent are takeoff accidents.

PILOT TRANSITION TRAINING

The opinion of Boeing instructor pilots who have trained hundreds of airline pilots indicates favorable and unfavorable airplane characteristics affect pilots' ability to make precision landing touchdowns. The length of the bar indicates relative magnitudes.

3•2 *Safety Trends*





3•3 *Instructor Pilot Opinion*

The following are the conclusions of Boeing instructor pilots:

Pilots gradually adapt to new instruments and cockpits.

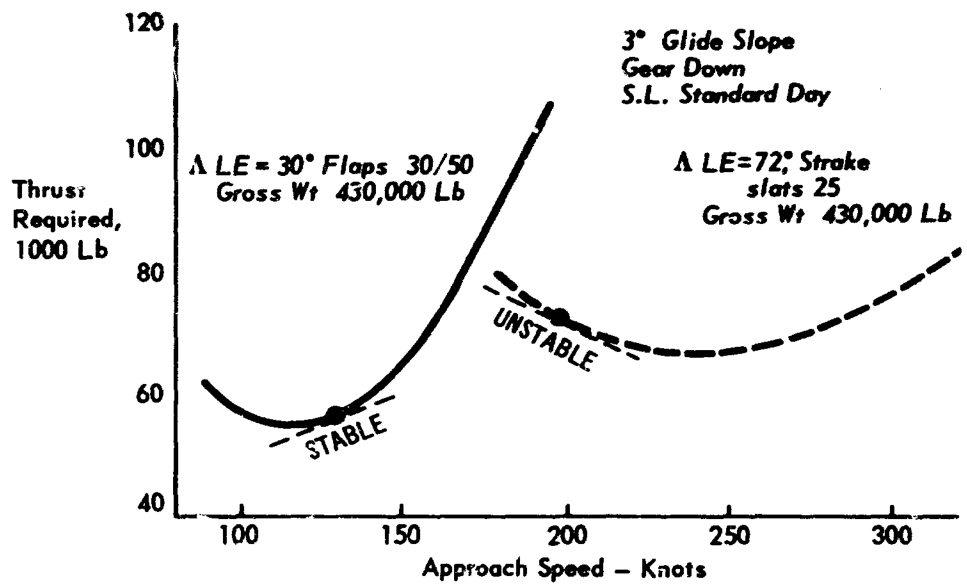
Pilot transition problems are concentrated in the visual phase of final approach and landing.

Qualified airline pilots handle instrument flight readily providing they have been given time to accommodate to new instruments and arrangements.

The major problems in achieving precision landings, especially after a low visibility breakout, are the visual references and aircraft attitude, the approach speed and speed stability, and flare characteristics and precision of response to control application.

Trainee pilot tension is extreme in some individuals.

3•4 *Speed Stability*



Landing Safety Characteristics

Low approach speed is important for safe all weather landings since turn radius is reduced, small directional corrections are accomplished with less roll upset, and pilot time to perceive, decide, and act is increased. Speed stability causes the airplane to return easily to the stabilized speed and attitude selected by the pilot after gust disturbances and height corrections have been initiated by the pilot.

The airplane "flies itself" rather than demanding continuous control input due to its speed stability.

Landing in the wings aft position is possible. The landing speed is increased appreciably and the landing requires additional pilot attention as the airplane speed stability is reversed. The B-58, F106, and F102 are examples of airplanes which operate under these conditions.

Design for Safety

OPERATIONAL DESIGN CONCEPTS

The B-2707 operational design concepts essential to flight safety are:

Provide landing and takeoff characteristics conforming to airline pilot characteristics and capability.

Provide the pilot the option of reverting to subsonic cruise speeds and altitudes without significant loss of range or reserve fuel.

Optimize the supersonic cruise characteristics without compromise of landing features essential to safety.

DESIGN SAFETY CHARACTERISTICS

The B-2707 has two basic shapes:

A slow-speed landing configuration similar to that of the Boeing 707 and 727, and the DC-8 including a high lift system, slow approach speeds, conventional handling qualities, approach attitudes, and visibility.

A supersonic cruise configuration designed for high speed stability and control, maximum lift/drag ratio, and simple operating procedures.

The variable sweep wing provides these two aerodynamic shapes and the capability during the Phase III program to:

Test and verify the operational trade-offs between approach speeds, body attitudes, and flare characteristics at various wing flap positions and thrust levels.

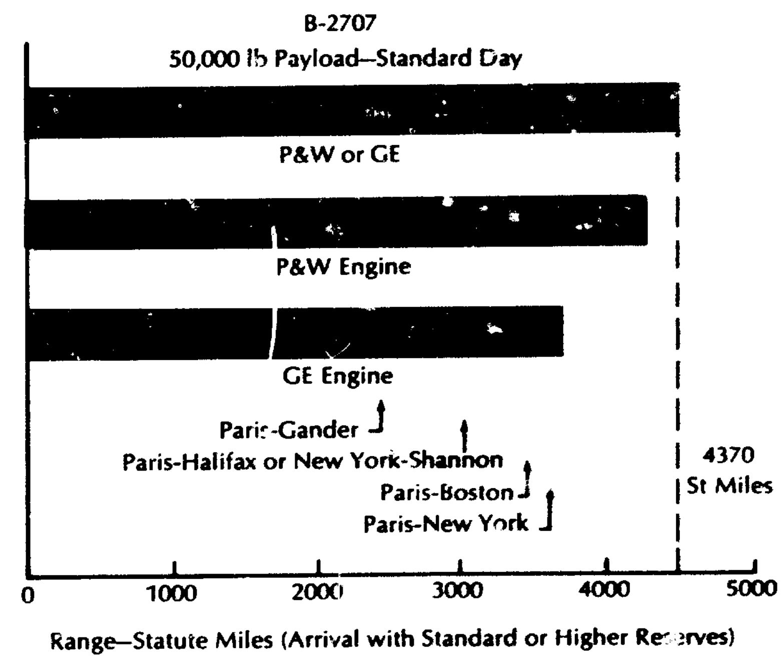
Evaluate powerful, precise roll controls independent of the constraints of elevator pitch control and trim systems.

Harmonize and tune all of the controls for precision cross-wind approaches.

Evaluate improved pitch and direct lift controls without compromising roll control.

Evaluate leading-edge and trailing-edge flap systems to provide nose-down approach attitudes if desired by airline pilots.

3•5 *Subsonic Range Characteristics*



Analysis of potential world routes shows:

The pilot of the B-2707 can revert to 4-engine subsonic cruise at any point on the North Atlantic routes and proceed with confidence to his destination, other major airports or return to his departure point.

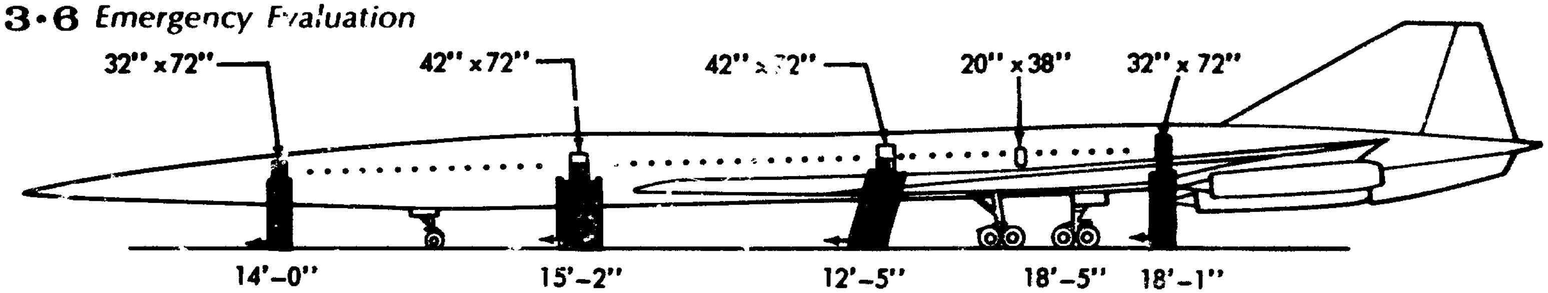
The Paris-New York route segment is shown as an example of this operational flexibility.

The B-2707 can land at enroute alternatives, after subsonic operation with standard or higher reserves, or proceed subsonically to the planned destination with some reduction in planned fuel reserve.

Emergency Evacuation

Passenger safety is foremost in the design of the passenger cabin. In the remote event of an emergency evacuation of the SST, the passenger is afforded the most advanced and reliable emergency means of egress from the airplane. The 42-inch wide doors are uniformly distributed throughout the cabin and cabin attendants' seats are immediately adjacent to each exit to provide "crew experience" for the door operation and escape slide deployment. The 42-inch doors, in conjunction with double slides afford rapid double file evacuation of the passengers at a rate 2¼ times as fast as a single exit. Requirements of existing Federal Air Regulations and proposed amendments thereto are fully satisfied.

3·6 *Emergency Evaluation*



NOTE: DOUBLE SLIDE RATE– 84 PEOPLE/MINUTE SINGLE SLIDE RATE– 35 PEOPLE/MINUTE

Landing Gear Breakaway

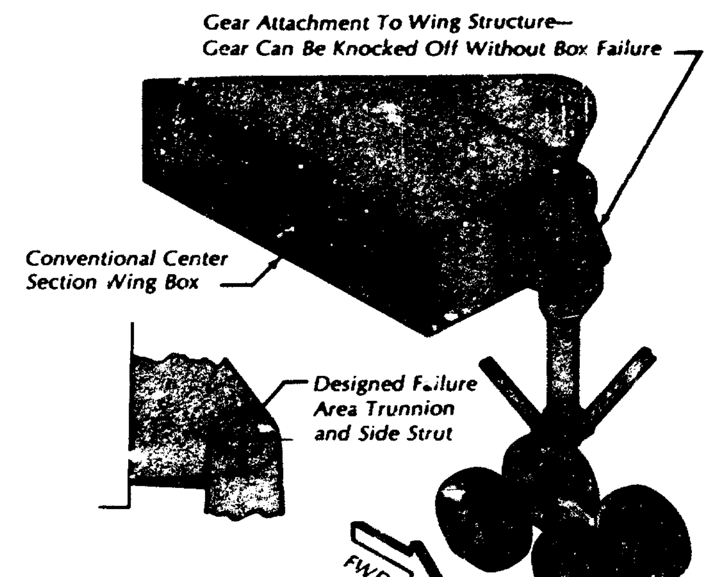
All gear include a fuse pin located at the connection between the drag and shock struts. This fuse pin is designed to fail when ultimate load is exceeded. After initial failure, the gear movement is as follows:

The forward main gear will fold aft until the gear contact a rigidly supported area of the wing box; then the gear trunnion will fail in tension (Fig. 3-7). The side strut will fail similarly. The gear will then detach itself from the airplane.

The rear main gear will fold aft and remain structurally attached but folded under the wheel well doors. The gear will remain in this position and support the airplane before engine nacelles contact the ground.

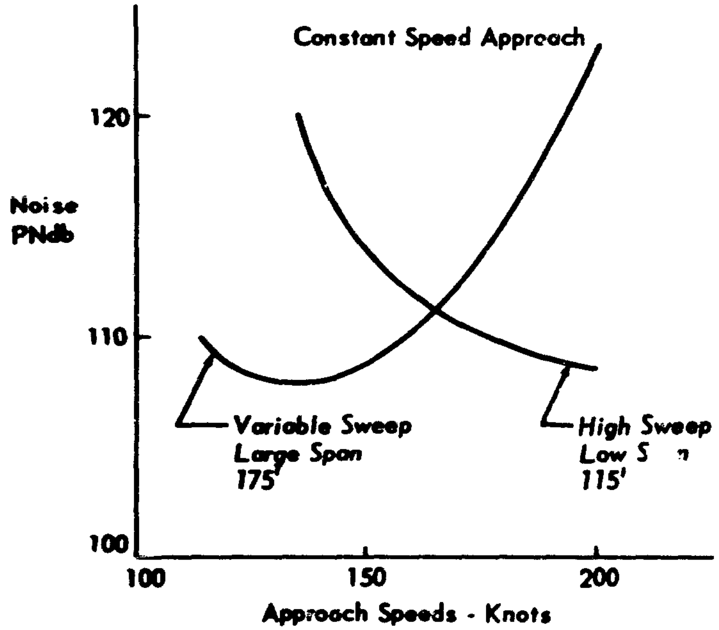
The nose gear will fold under the body after failure of the retraction linkage.

A safe landing can be made with one main gear down on each side of the airplane. The articulated forebody in the down position will act as a skid in the event of nose gear failure.

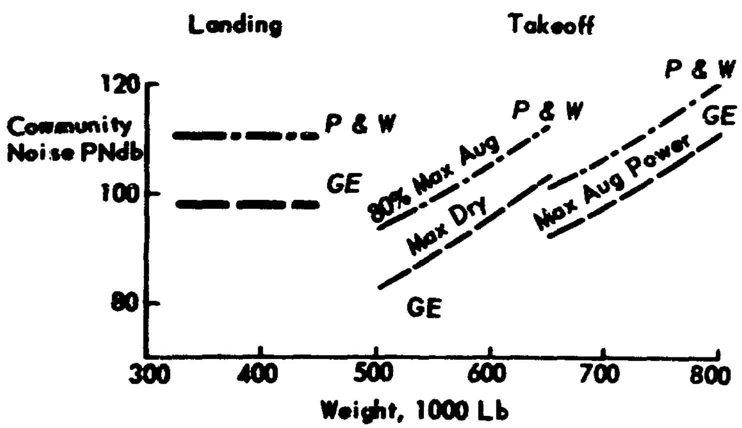


3·7 *Gear Breakaway*

3·8 *Effect of Span on Community Noise*



3·9 *Effect of Gross Weight on Community Noise*



Community Noise

Community noise associated with high performance engines and large airplane weights has been minimized for the B-2707 by use of the unique performance capabilities of the variable sweep concept and by the design of noise suppressors.

The large wing span coupled with an efficient high lift system of the B-2707 results in low thrust and consequently low noise at the low approach speeds as shown in Fig. 3-8. In contrast, a high sweep fixed wing concept results in *increasing* thrust (increasing noise) as speed is reduced. This characteristic presents a dilemma: If the approach speed is low, the noise is high; and, if the approach speed is high (for low noise) the landing distance is excessive. As indicated in Fig. 3-8, for approach speeds comparable to current subsonic jets (130 knots), the variable sweep concept produces significantly less noise than a comparable high-sweep, low span concept.

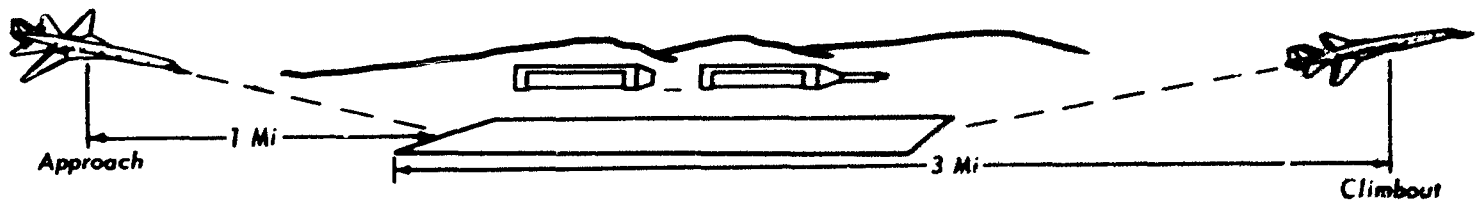
Calculated noise levels for the B-2707 are shown in Fig. 3-10. Significant noise suppression has been achieved through use of jet, compressor, and fan noise suppression devices. Engine compressor or fan inlet noise has been minimized through operation of the inlet variable diameter centerbody to produce near sonic speed at the inlet throat. Jet noise has been reduced through the use of the engine manufacturer's exhaust nozzle configurations. To further reduce noise, a decelerating approach (speed bleed-off) is accomplished by reducing engine thrust as flap extension is increased during the final phase of the approach.

It is significant to note that the B-2707 community noise characteristics are better than the 707-320B and within FAA objectives.

Boeing research and test of jet suppression concepts, see Figs. 11 and 12 indicate that further reduction in noise is possible.

The noise data shown in Fig. 3-9 is based on maximum takeoff weight (675,000 pounds) and maximum landing weight 430,000 pounds (GE) and 420,000 pounds (P&W). The variation of community noise with airplane weight is shown in Fig. 3-9. The FAA noise objectives for climbout are achieved with augmented thrust for the 675,000 pound airplane and with dry or partial augmentation for the 575,000 pound airplane. The B-2707 provides considerable flexibility in landing operations. Approach speed and noise level can be varied as a function of body attitude and flap position to best suit the needs of each airport community.

3·10 Community Noise



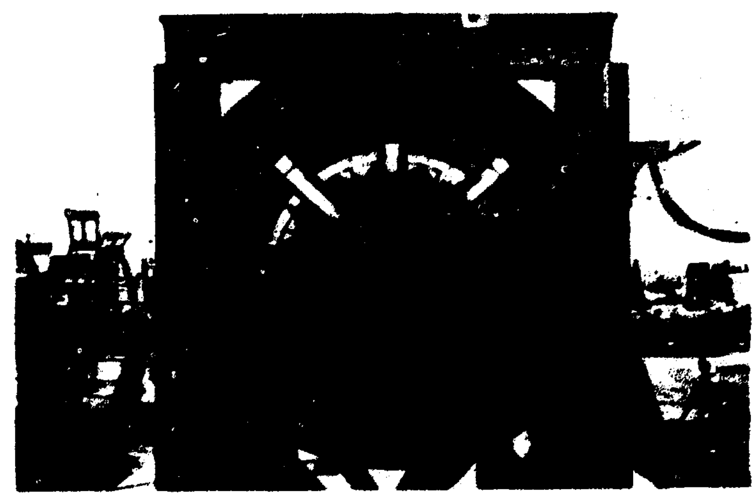
Noise—PNdB

	Approach		Climbout	
B–2707	B–2707 (GE)	B–2707 (P&W)	B–2707 (GE)	B–2707 (P&W)
Engine Manufacturers Demonstrated Suppressors	98 *	111 *	95	104
707–320B	124		122	

*Decelerating Approach

Boeing Sound Suppressor Concepts
(Full-Scale Test Rigs)

3·11 Chute Ejector



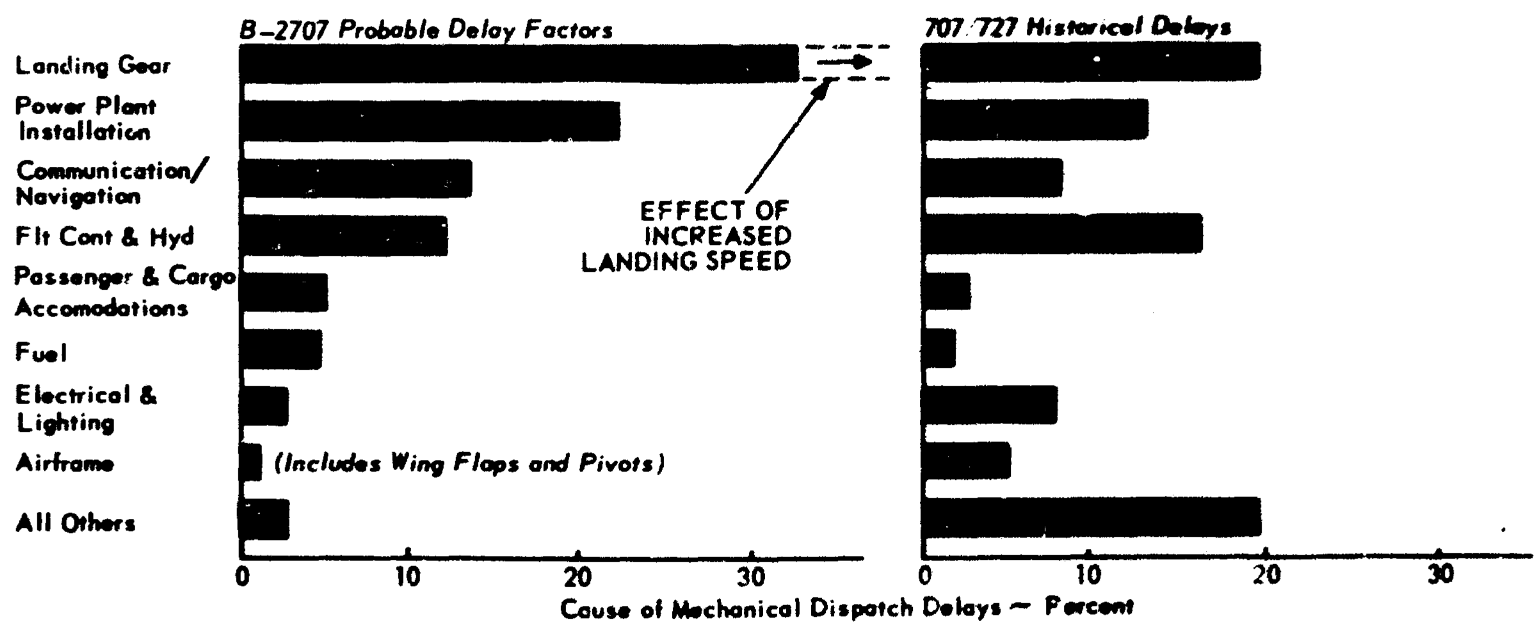
3·12 Scoop Ejector

Reliability—Maintainability

High daily airplane utilization can only be achieved by reducing ground times for throughstop and turnaround maintenance, fueling, cleaning of the airplane interior, and refueling. The passengers and cargo must also be unloaded and loaded during these ground intervals. The B-2707 is designed so that these normal planned activities can be accomplished in a scheduled routine compatible with airline schedules.

It is obvious that flaps and wing pivot are not a major contributor to low reliability or to high maintenance. The reduced landing speed permitted by their use results in large improvements in the highest contributor – *the landing gear*

3·13 *Dispatch Reliability*



Dispatch or mechanical reliability is more difficult to achieve than inflight reliability. Redundant installations for in-flight safety and reliability provide the capability to proceed safely to the scheduled destination for accomplishment of the necessary unscheduled maintenance.

Achievement of dispatch reliability depends primarily on the amount of unscheduled maintenance required after each landing and the time available prior to the next scheduled departure.

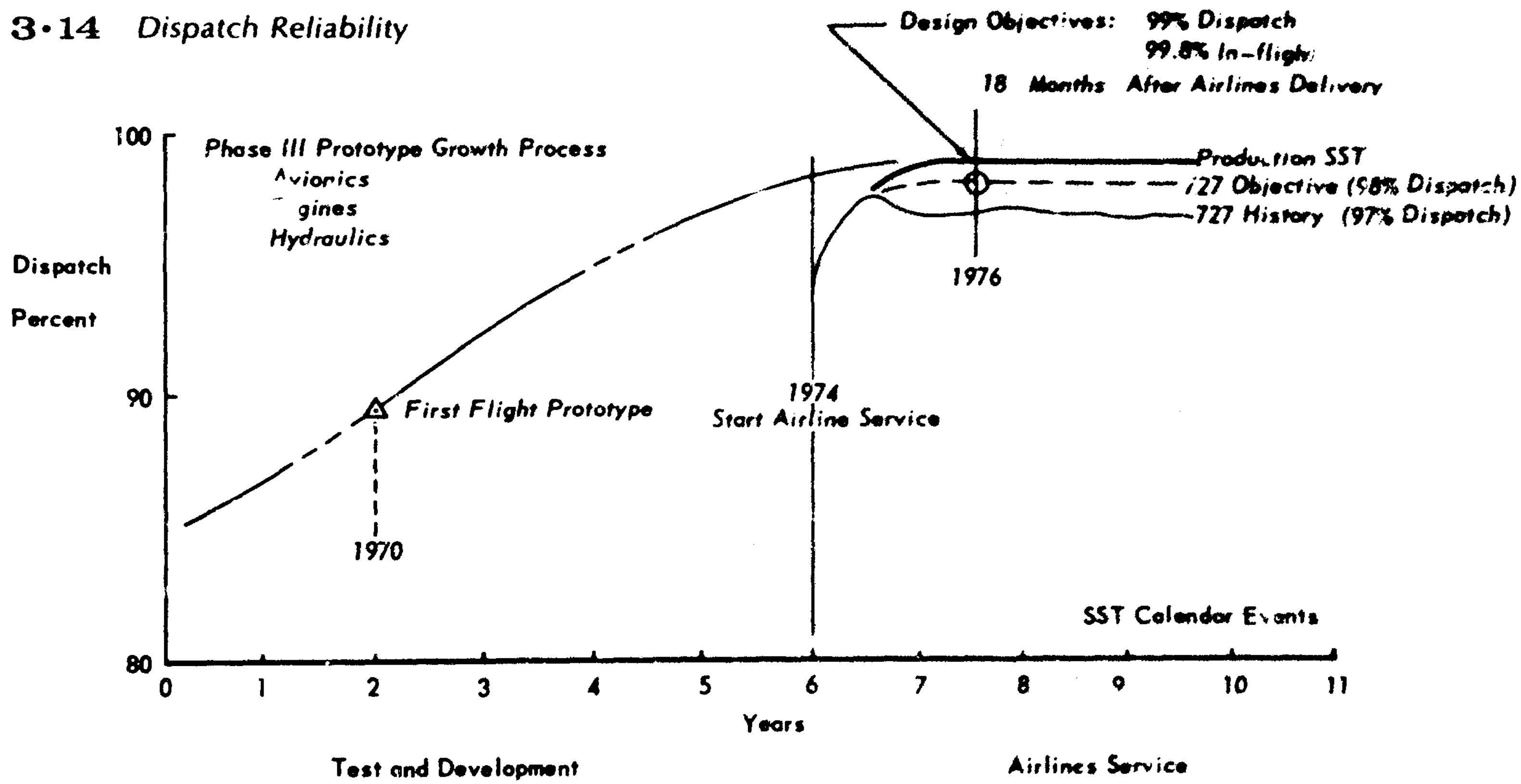
Unscheduled maintenance arises from random mechanical failures or malfunctions and is directly related to the reliability of the airplane. Dispatch reliability, therefore, is contingent on mechanical reliability and the time necessary to:

- Identify the failed component
- Remove and replace the failed component
- Test and checkout the system to verify the repair

Dispatch Reliability Achievement

Reliability is attained by a growth process which starts with design, continues through the development phase, and is finally achieved and sustained by continuing team effort of the designers, suppliers, and airline maintenance and management personnel.

3·14 Dispatch Reliability



This prediction is based on:

Boeing 707 and 727 history

SST Assumptions:

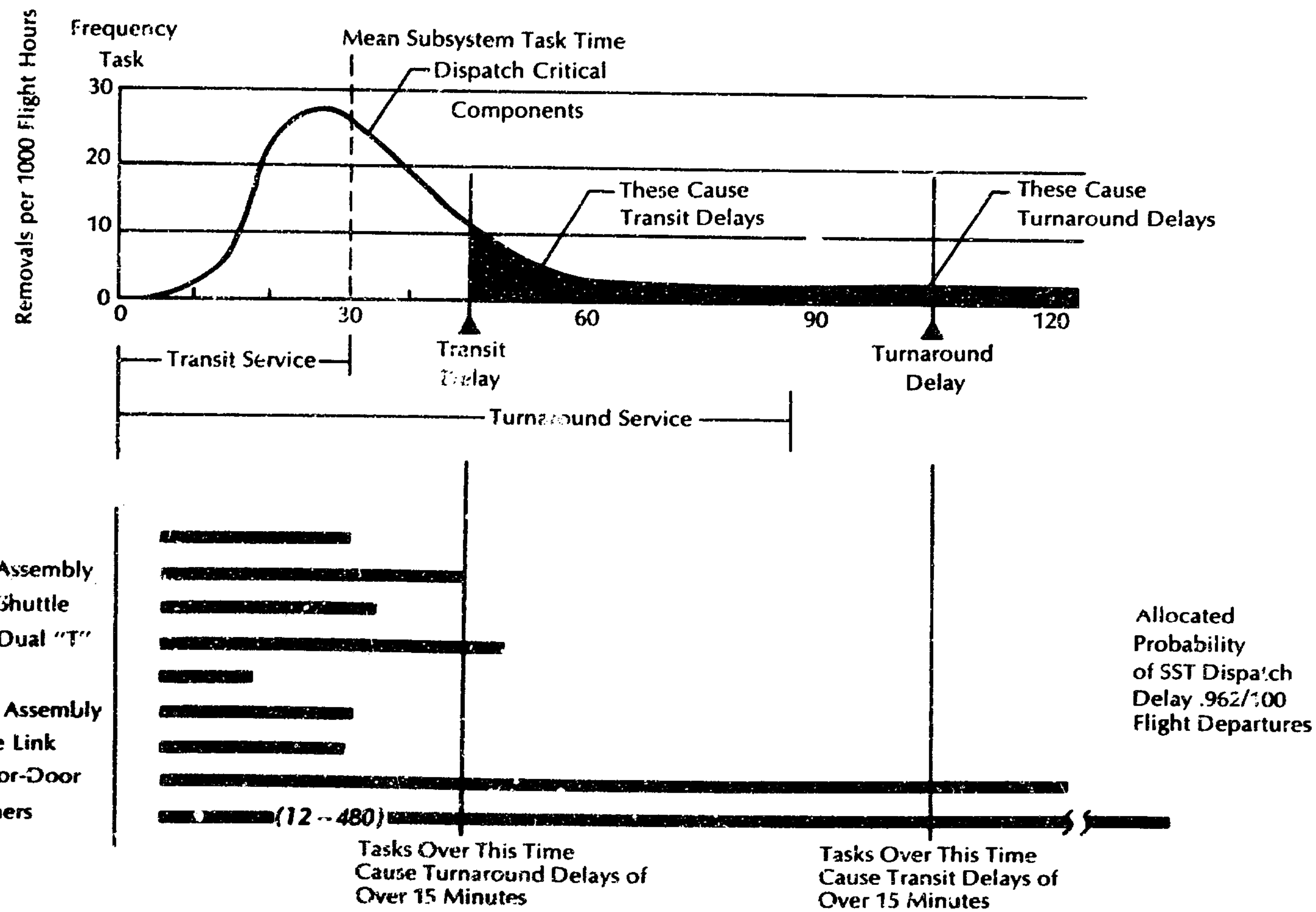
1.75 hour SST average flight
30 minute throughstops, 90 minute turnaround
10% throughstops, 90% turnarounds
Delays past 15 minutes counted

V1-B2707-1

Dispatch Reliability Design Approach

The landing gear is the major delay causing subsystem on subsonic airplanes and is projected as the major delay causing subsystem on the SST. This subsystem is used in the following example to show the interrelationship between scheduled ground time, maintenance frequency, and maintenance time. The data shows that the tires and brakes, which are the most frequent causes of dispatch delay, can be removed and replaced on the B-2707 without causing a transit delay.

3·13 *Landing Gear Maintenance Times*



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Technical Features and Tests

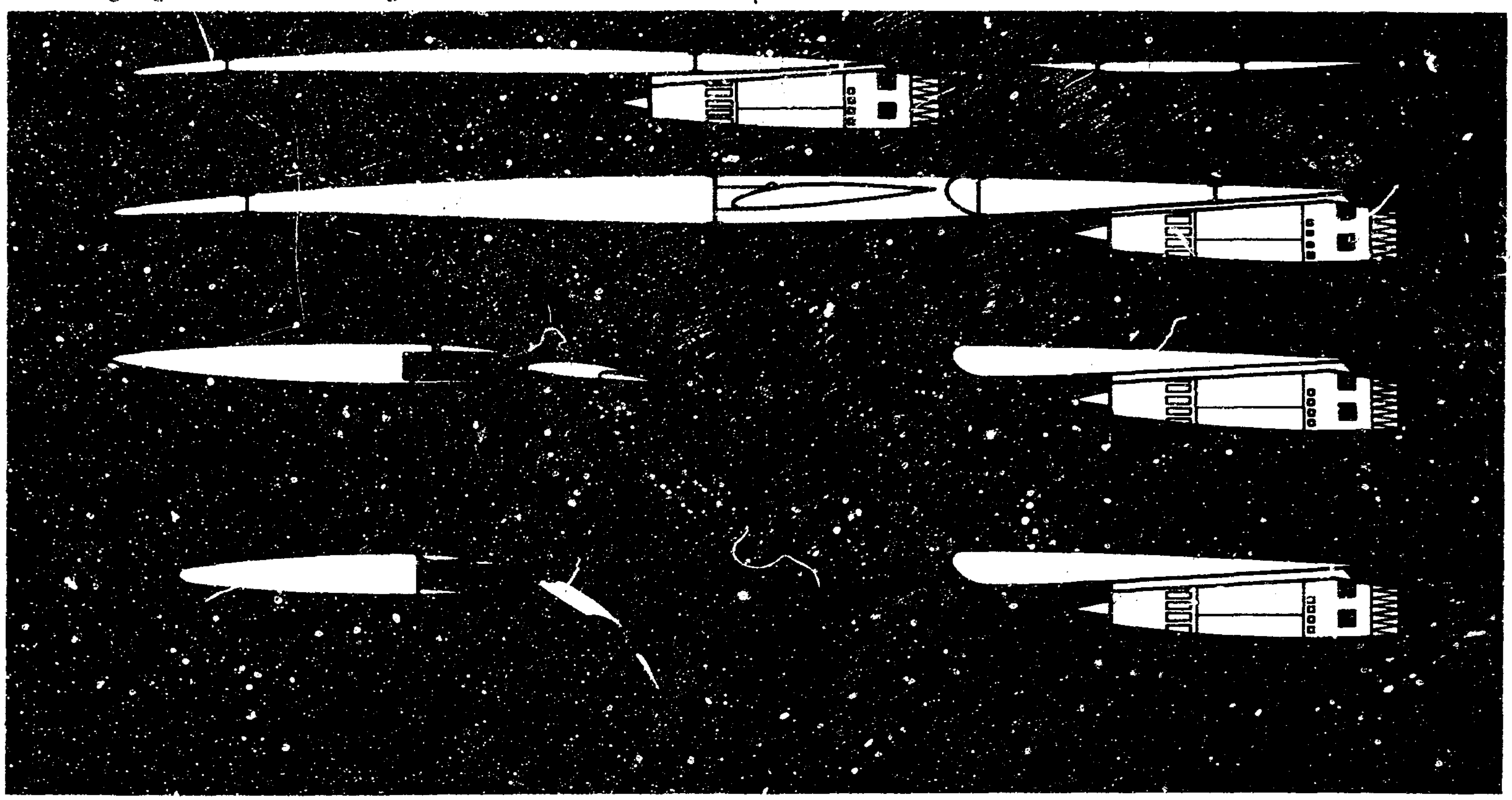
Integrated Wing

The B-2707's integrated wing is a major step forward in the development of an efficient, lightweight configuration for a variable sweep wing. A 25 percent improvement in wing stiffness reduces weight and increases wing fuel volume over an equivalent configuration using separated surfaces.

The wing sweeps forward to provide a subsonic cruise position with aerodynamic performance equal to today's jet airplanes, without jeopardizing supersonic cruise performance. The trailing edge flap, which stows within the supersonic wing contour, extends to form the trailing edge of the subsonic wing. In addition, the highly-swept rounded leading edge of the horizontal tail performs efficiently at subsonic speeds.

Sweeping the wing forward and extending the flap to the low speed position permits higher gross weights at a given engine power setting than a fixed-wing supersonic airplane. Airplane attitude remains at a comfortable angle because of the high lift flaps. The flaps also protect the engines from foreign objects and spray from the wheels. Clean air for the engines flows in over the wing.

The integrated wing insures significant growth potential for the B-2707.

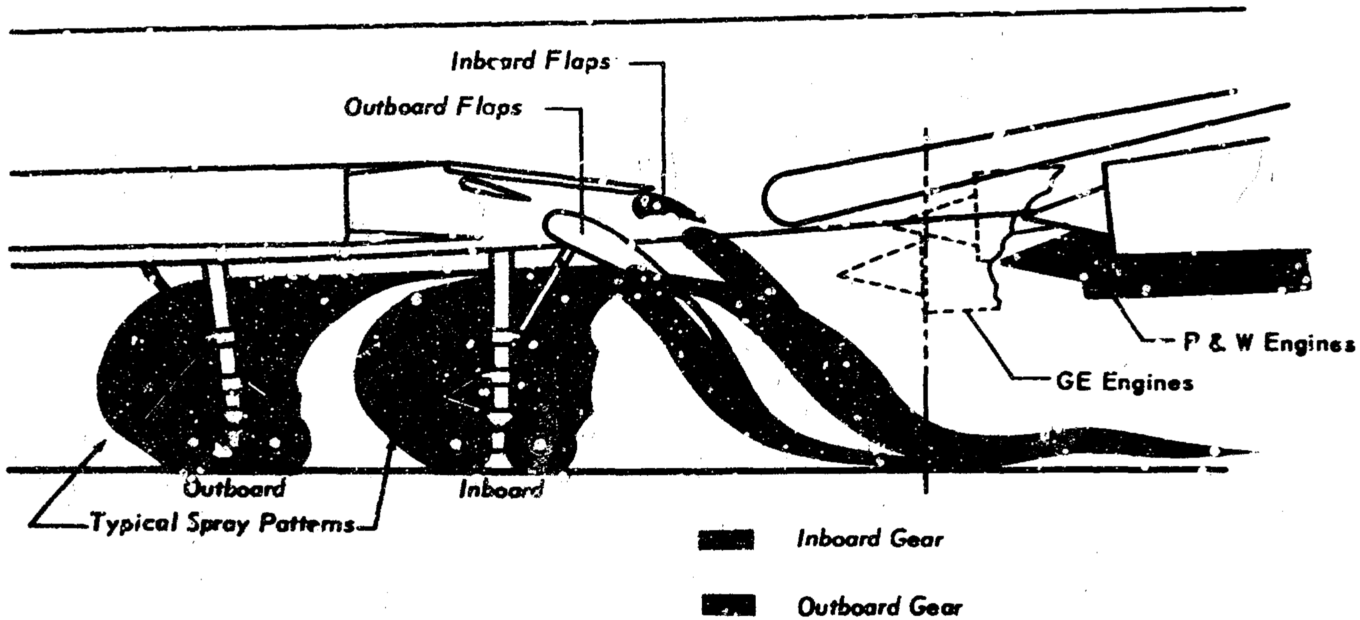


4 • 1 *Integrated Wing*

Ingestion Prevention

Airplanes with aft-mounted engines are susceptible to water and foreign object ingestion unless protection is provided. In the B-2707 design, the flaps perform a dual function. They serve as high lift devices and deflect any material thrown off the wheels away from the engine inlets. Extensive development tests on subsonic and supersonic transport designs have demonstrated the necessity and adequacy of this type of natural protection.

4·2 Engine Inlet Protection



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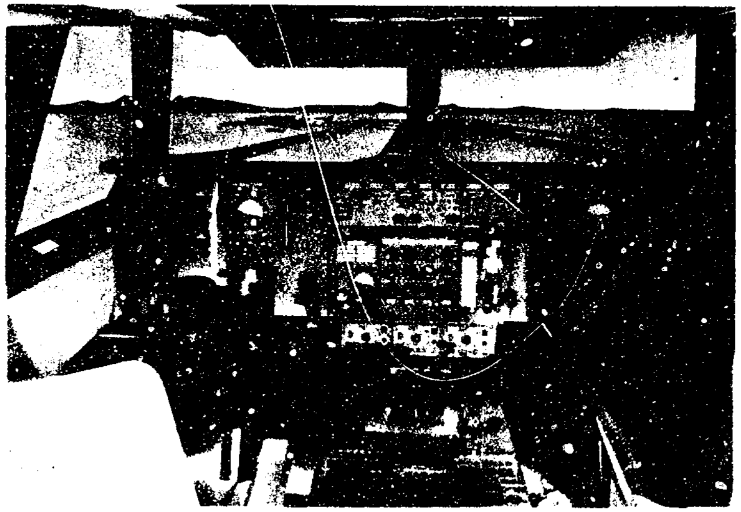
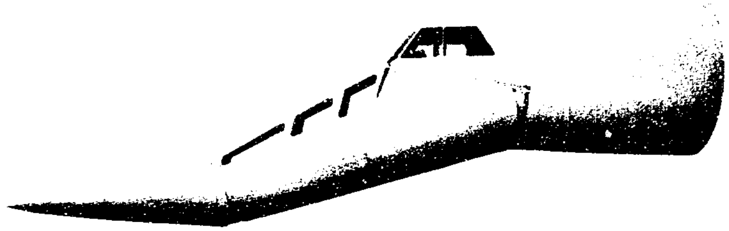
4•3 *Cockpit Mockup*



4•4 *Nose Position–Supersonic*

4•5 *Nose Position–Subsonic*



Flight Deck

The B-2707 flight deck reflects many airline pilot and flight engineer recommendations and reflects lessons learned from the B-70 and F-12 flight programs, as well as from many dynamic simulation studies.

The sensitivity and deadband requirements of the flight instruments are increased over those of existing jet transports to satisfy the piloting requirements ranging from a low visibility approach and landing to cruise at Mach 2.7. Closed circuit television allows pilot surveillance of the landing gear and taxiway edges during ground maneuvering, and improves vision of the approach lights during low visibility landings. Communication, navigation, autopilot, and flight direction controls are located high on the center instrument panel to facilitate scanning and observation and to reduce pilot workload. In spite of the more demanding requirements of both supersonic flight and Category III landings, the layout of the displays and controls maintains similarity with current jet transports to minimize flight crew orientation and training.

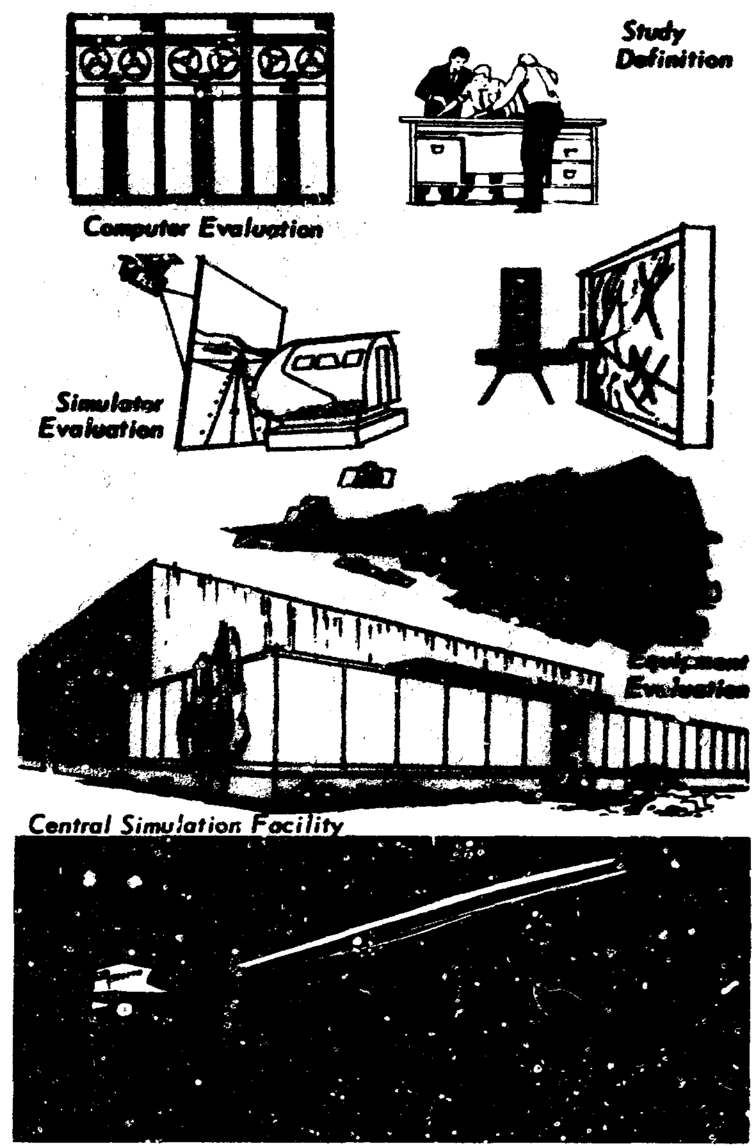
The B-2707's doubly articulating nose provides low drag and a large field of forward vision during supersonic cruise and more vision than the best of current jets for subsonic and landing operations. Dual drive systems and the capability to free fall to its down position provide reliable operation. If the nose cannot be lowered, sufficient vision for a safe landing remains through the most forward windows. The design minimizes the air data pitot-static position error and weather radar antenna alignment problems associated with the various SST "droop nose" concepts; it provides adequate clearance for ground maneuvering; and it may serve as a skid and energy absorber in the event of nose gear extension failure.

Flight Simulator

The role of dynamic flight simulators in developing high performance aircraft has increased dramatically over the past two decades. The illustrations portray the role of these tools in the detail design, development, and evaluation of the flight control systems of the B-2707. In addition, the effects of turbulence on the dynamic operation of the airplane are evaluated. Operational margins and procedures are determined for both normal and abnormal operating conditions, and the training of flight test crews is aided by the simulators.

The technical areas involved include aerodynamics, automatic control, human engineering, avionics, mechanical equipment, propulsion, and structures. Typical interface problems that have been studied on the B-2707 flight simulators are: structural loads in turbulence as a function of stability augmentation system configuration, interrelationship between flight deck design and pilot work load, engine inlet environment as a function of the stability augmentation system design, and hydraulic system power requirements.

A centralized facility will be built to house developmental cab, an experimental high-temperature actuation subsystem, and special computing equipment, all built during Phase IIC. A full-scale operating mockup of the flight control system, similar to that used in the Boeing 727 program, is included as a major part of this facility.



4•6 *Flight Simulator Functions*

Structural Design

Proven structural concepts are used throughout the B-2707:

Body—Conventional skin and stringer construction

Wings—Main center section extending from pivot to pivot and two outboard sections; all of skin and stringer construction

Empennage—Multi-spar and skin and stringer construction in both horizontal and vertical stabilizers

This type of primary structure permits use of standard repair methods and equipment. Design is such that failure of any structural element will not jeopardize the airplane's safety.

Titanium-skin honeycomb is used in the secondary structure to provide high efficiency and low weight. Completely sealed, long-life panels also provide a high degree of aerodynamic smoothness.

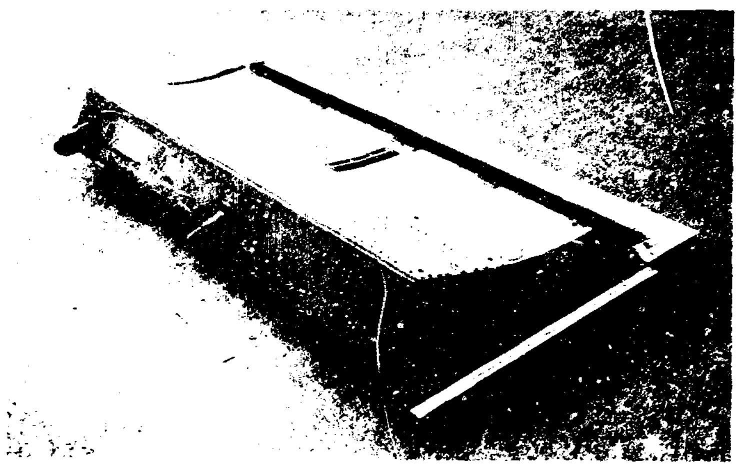
Primary and secondary structure is assembled mainly with mechanical fasteners. Access is provided for inspection and maintenance. Structure is designed for not less than 50,000 hours of service life.

The airplane's service life is being designed to criteria developed by the United States Air Force and the Federal Aviation Agency. Full advantage is taken of the comparative-type approach used on the Boeing 747. This approach, based on integration of fatigue analysis, test, and service experience with large fleets of contemporary Boeing commercial jetliners, relates actual fatigue performance with that predicted by analyses and tests.

Over the past year, Boeing has bought 40,000 to 50,000 pounds of titanium mill products per month for development and fabrication. Determination to exploit the highly desirable structural and thermal characteristics of titanium metal in airframe manufacture has resulted in over 500 research projects. Some 70 production oriented processes have been completely documented. The necessary knowledge for routine and economic use and manufacture of titanium has been established. Boeing is fabricating about 650 pounds of titanium bulkheads, firewalls, ducts, tanks, and fittings for each 727 airplane

4•7 *Riveted Aluminum Spoiler Panel*

50 Details — Wt. 37.25#
1219 Fasteners — Cost $1100



4•8 *Bonded Titanium Spoiler Panel*

38 Details — Wt. 26.71# Wt. Save 10.54 28%
48 Fasteners — Cost $940 Cost Save $160 14.5%

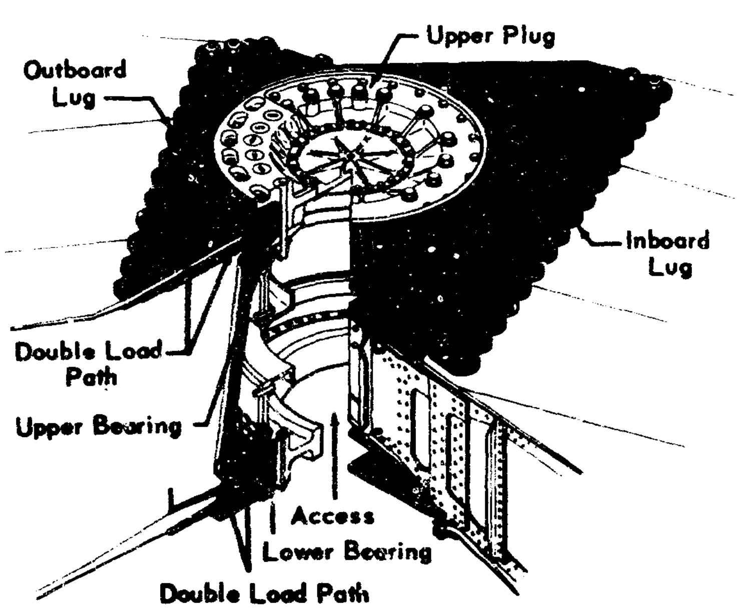
Wing Pivot

The wing pivot (Fig. 4-9) is a simple, double, load-carrying design at the upper and lower wing skin surface.

The journal bearing consists of an outer race, a floating race coated with a layer of teflon fabric on each face, and an inner race. Tests indicate a service life for the bearing that exceeds total airplane life. The pivot structure has been designed to fail-safe criteria.

The bearing will provide reliable, trouble-free service for the life of the airplane. This has been proven by extensive testing including a full-size test conducted under airplane design loadings and environment in which the bearing has completed more than 30,000 cycles, exceeding airplane service life requirements. Upon inspection the bearings were in excellent condition and showed no appreciable wear.

4•9 *Wing Pivot*



4•10 *Wing Pivot Test*

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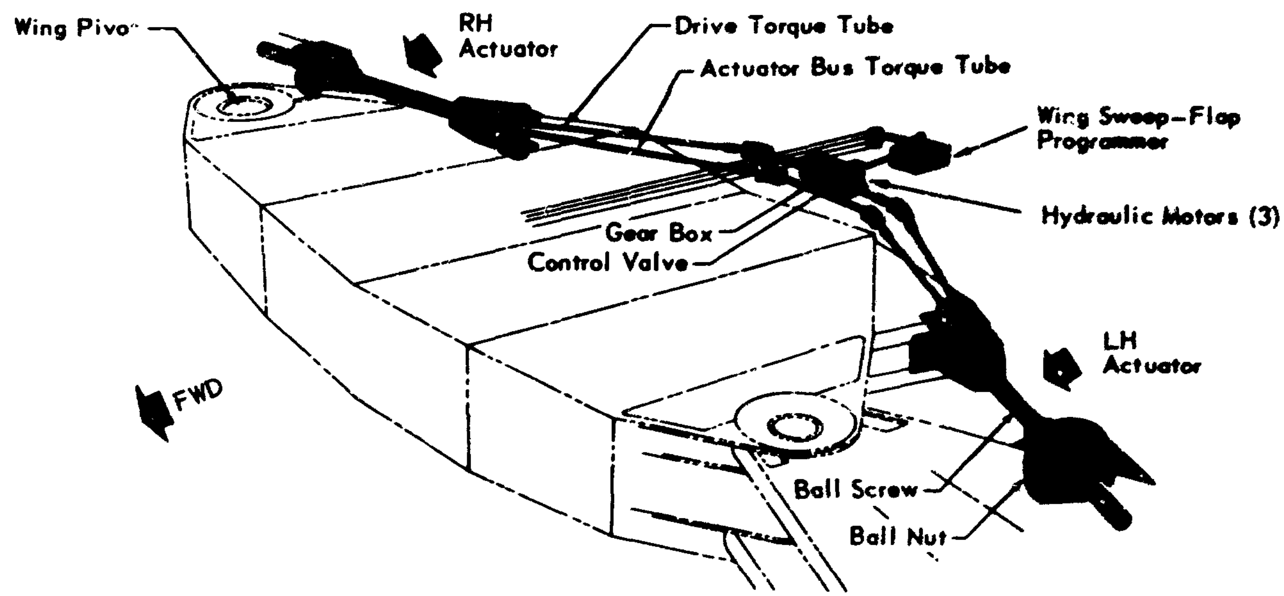
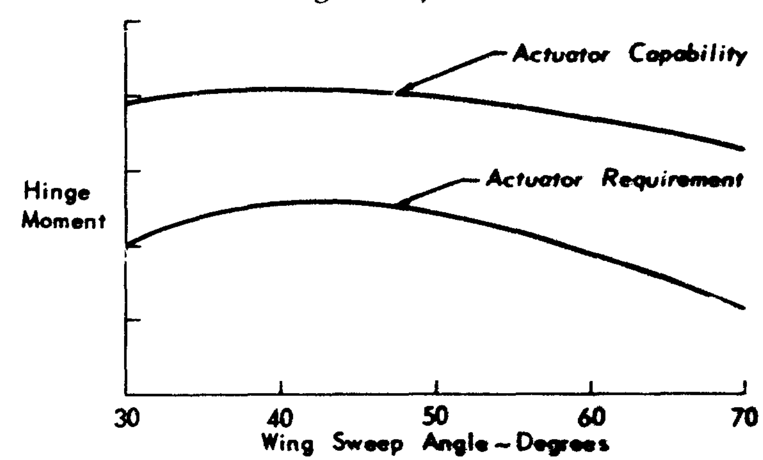
4•11 *Wing Sweep Actuation System*



4•12 *Wing Sweep Actuation*



Wing Sweep Actuation System

The wing sweep actuation system is designed to provide structural and operational redundancy. Three hydraulic motors operate from three independent hydraulic systems. Any one of the three motors will actuate the wing sweep system at one-third normal rate. The gear box supplies power through a torque tube to each wing sweep actuator. An additional bus torque tube connects both actuators directly. This bus tube normally is unloaded, but can operate either actuator in case of a failure of a normal drive tube. The wing sweep actuator is a ball screw which is designed with dual structural and operational load paths throughout.

In the extremely unlikely event of a multiple failure in the drive system, an asymmetric shutoff stops operation immediately.

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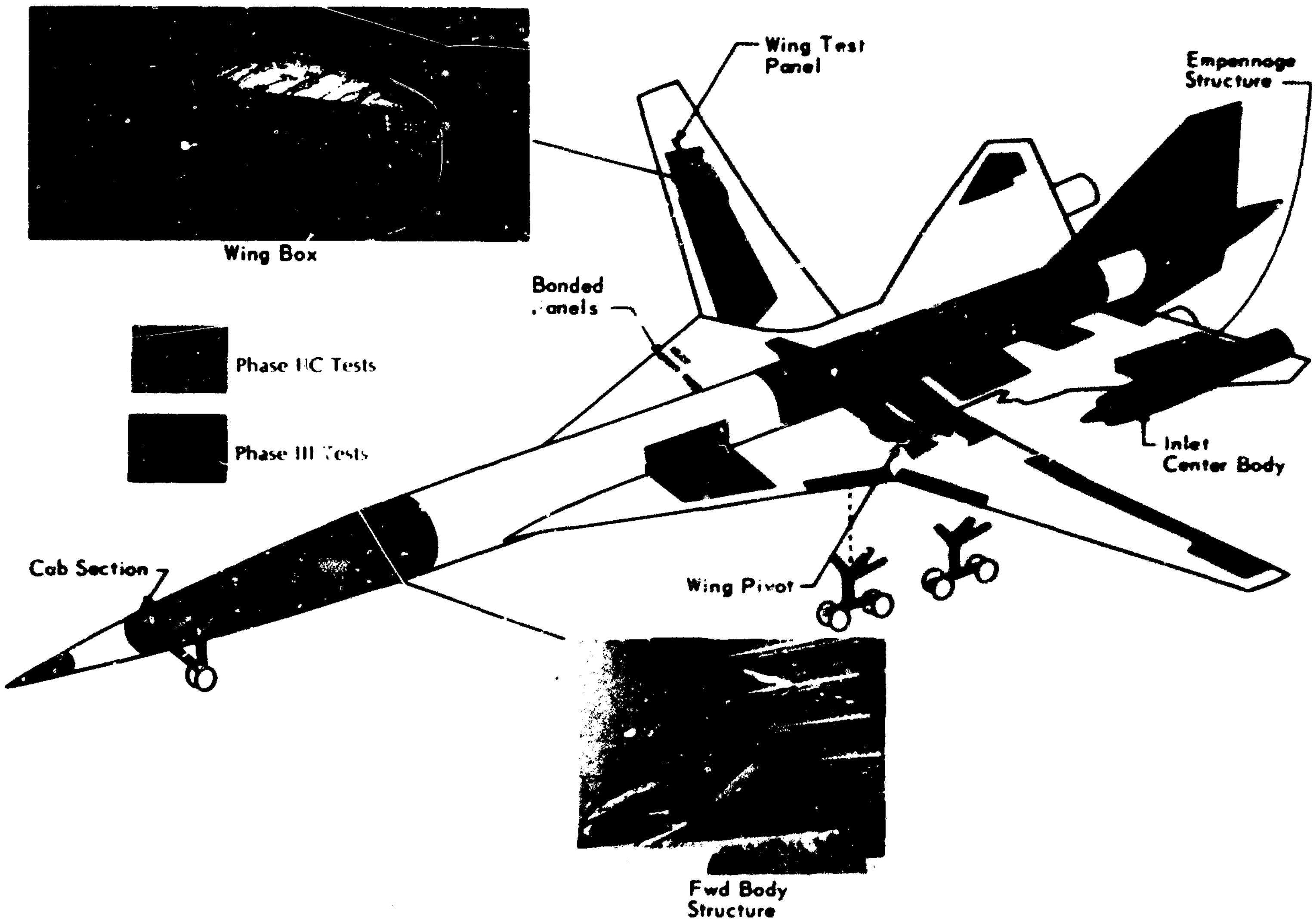
4·13 Structural Testing



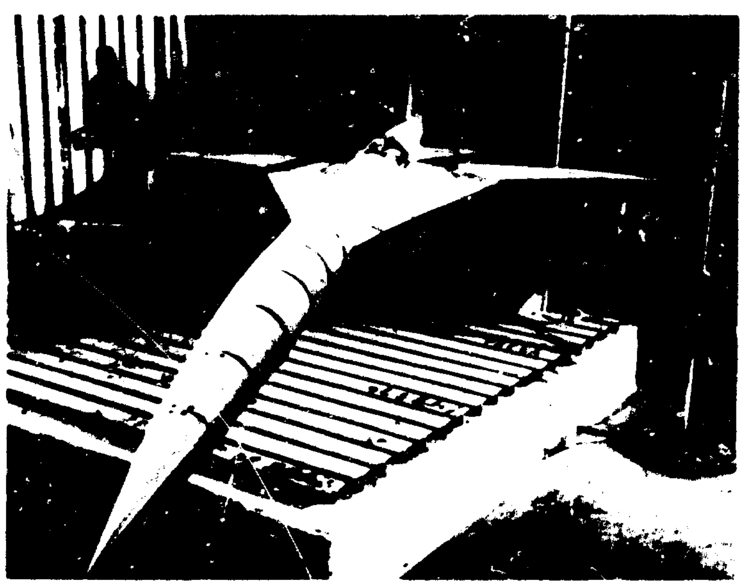
Structural Test Program

Elements of the extensive structural test development program are illustrated in Fig. 4-13. The inserts show examples of component tests already completed. The fuselage fail-safe test demonstrated the ability of the structure to sustain damage without catastrophic consequences. The wing test confirmed the thermal stress analysis and, like the body test, demonstrates the ability of the structure to sustain load after extensive damage.

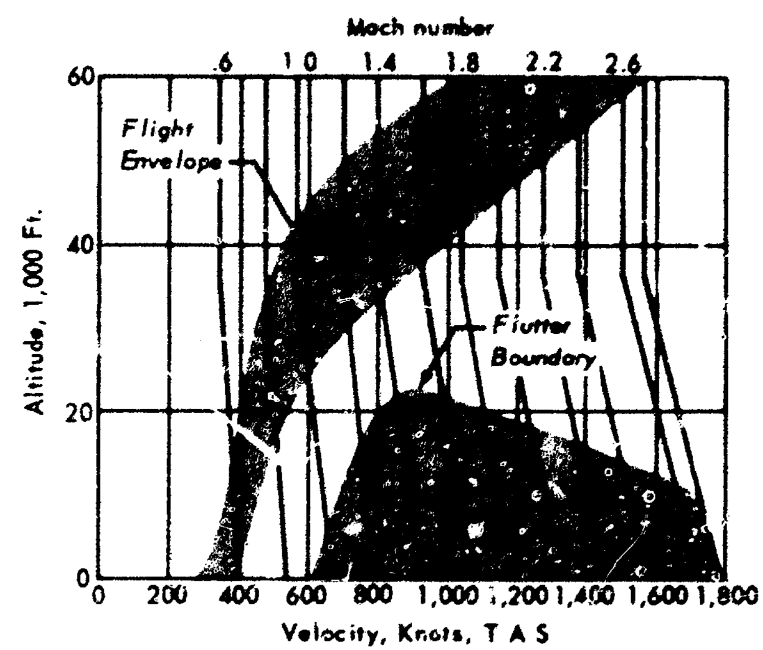
The knowledge gained from these tests is invaluable in the development of long-life structure. The structural test program is scheduled to support both the first flight of the prototype and the final structural design of the production airplane.

The flutter boundary of the airplane has been established by analyses and substantiated by flutter models. The boundary is greatly beyond the flight envelope to allow a wide margin of overspeed. Fig. 4-15.

4•14 *15-Foot Flutter Model*



4•15 *Flight Envelope and Flutter Boundary Relationship*



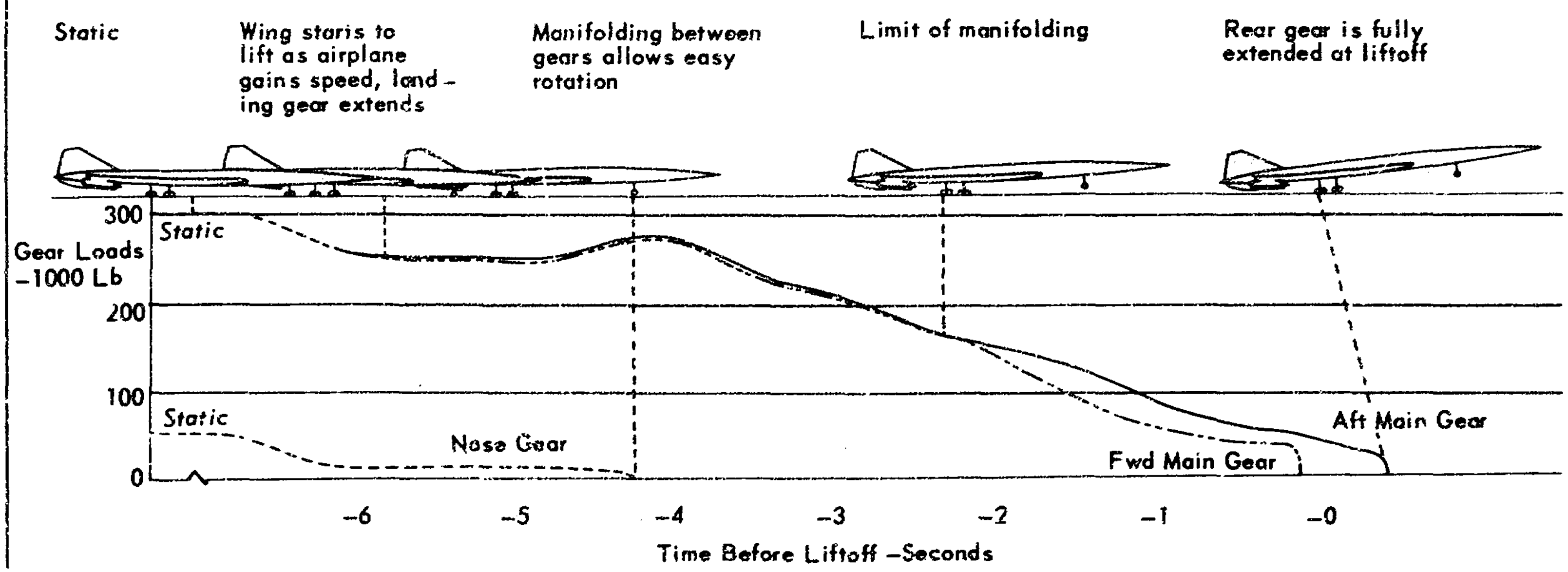
Landing Gear Characteristics for Soft Landings

The B-2707, being a member of the new "large airplane" family, makes use of the latest techniques in landing gear design and arrangement to allow takeoffs at high gross weights and provide inherently soft landings. As the airplane touches down, the rear gear shock strut absorbs most of the impact with a long stroke oleo. The forward main gear shock strut checks the rotation of the airplane as the wing lift decreases. As a result nose gear contact with the runway is controlled to complete the soft landing.

An interconnecting hydraulic manifold equalizes the braking and taxiing loads between the forward and rear main gear. This manifold permits the airplane at any gross weight to rotate freely when the pilot initiates takeoff.

The long stroke oleo strut of the rear gear continues to extend during the takeoff run to assure that the ventral fin clears the runway at the attitude required for takeoff.

4•16 *Gear Loads—Takeoff*



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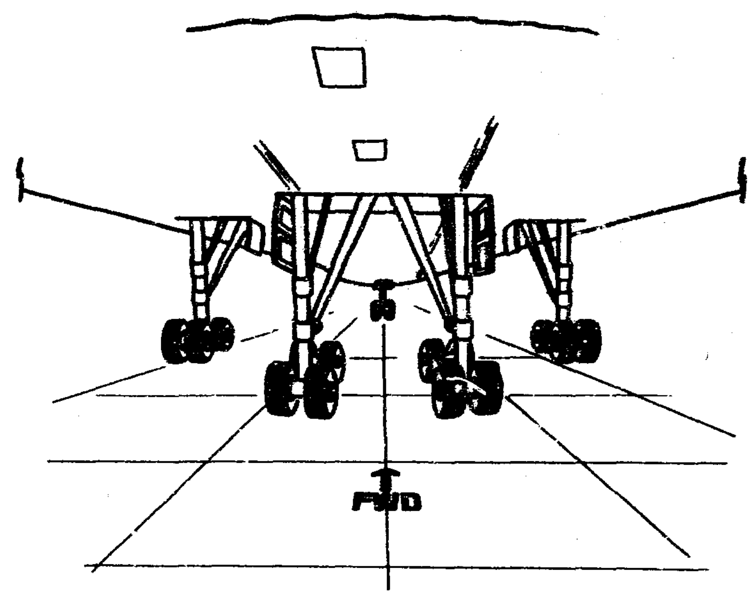
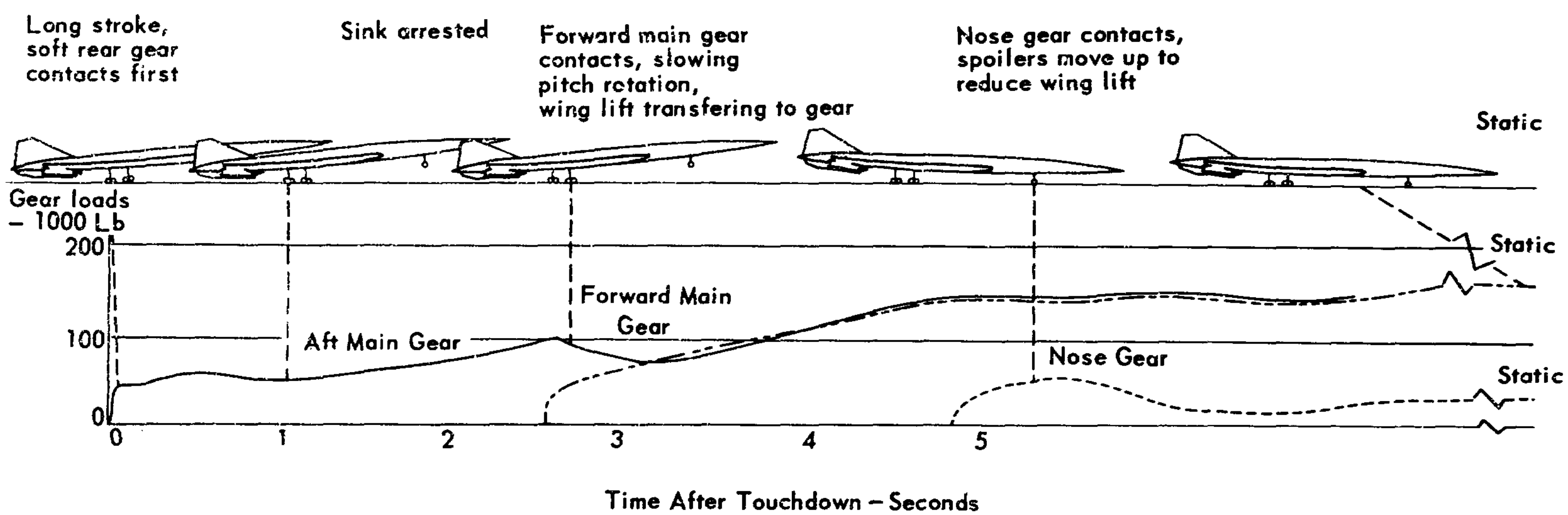


4•17 *Gear Loads—Landing*



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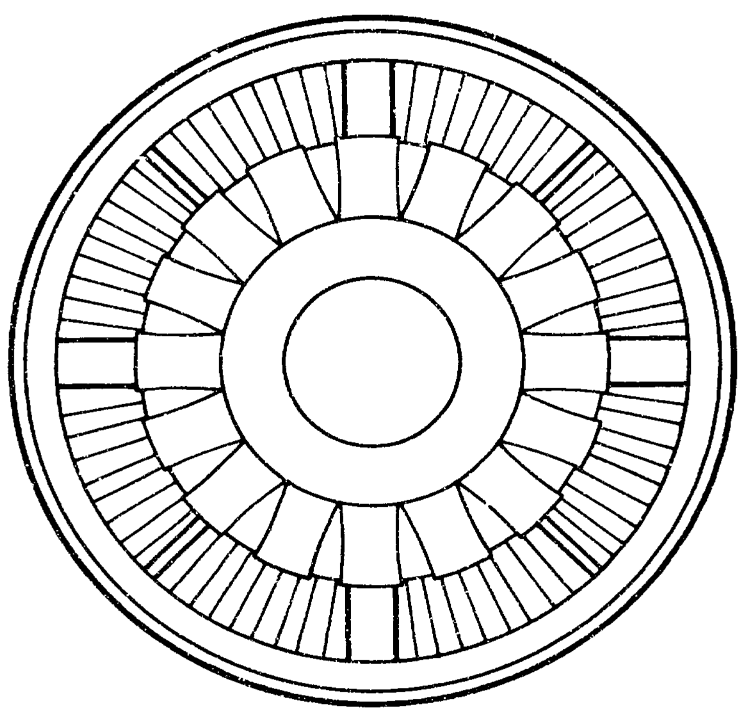
4•18 *100 Percent Symmetrical Inlet to Avoid Distortion*



AIR INLET SYSTEM

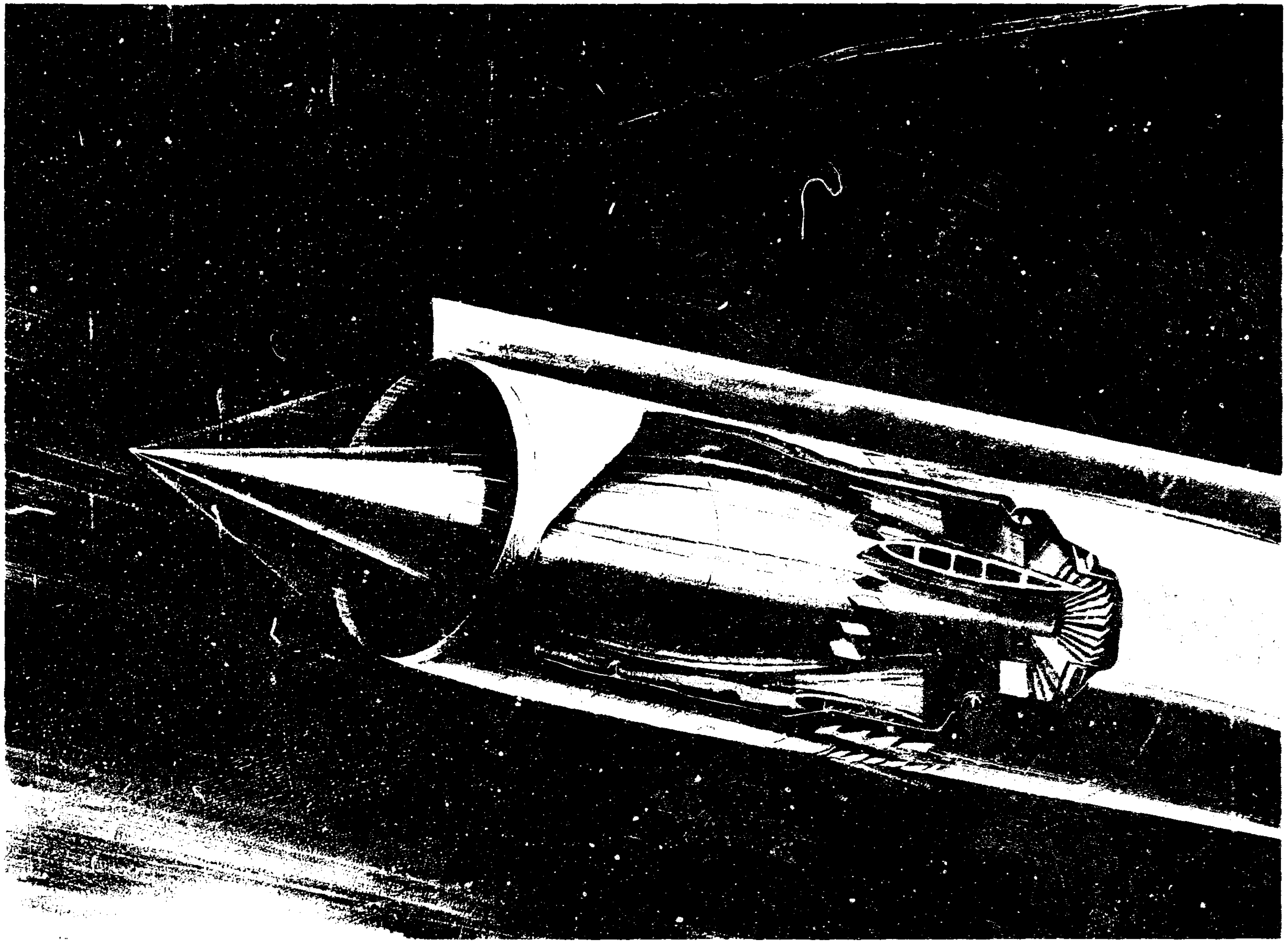
The fundamental principle of the Boeing supersonic inlet is to decelerate the air passing through it to the engine with as little disturbance as possible. Only in this way can the air be delivered to the engine compressor with maximum recovery of the available pressure and an optimum distribution of flow. The annular flow passage through the inlet provides a straight-through flow channel into the compressor, while the variable diameter centerbody and cowl bypass system are controlled to provide optimum internal contours and inlet-engine airflow match at all conditions. The inlet combines the performance advantages of internal flow compression with minimum external drag.

The inlets are located underneath the wing and tail to use these surfaces to smooth and direct the flow to the inlets under all airplane operating conditions. This sheltering effect makes practical a relatively short, cylindrical, pressure-vessel inlet design.

The Boeing inlet is designed to eliminate flow disturbances and engine inflow distribution effects during transient conditions that might otherwise cause the engine compressor to stall.

Inlet flow stability is excellent. The control system uses a simple, reliable aerodynamic feedback to control the inlet geometry for peak performance. To further stabilize the flow under sudden disturbance conditions Boeing has developed a flow monitoring system located in the inlet throat.

During landing approach and ground operation the inlet throat is adjusted to create a sonic flow condition which eliminates compressor whine noise, without any adverse effects on the engine flow distribution.



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4•19 *B-2707 Axisymmetric Inlet*

Engine Inlet Test

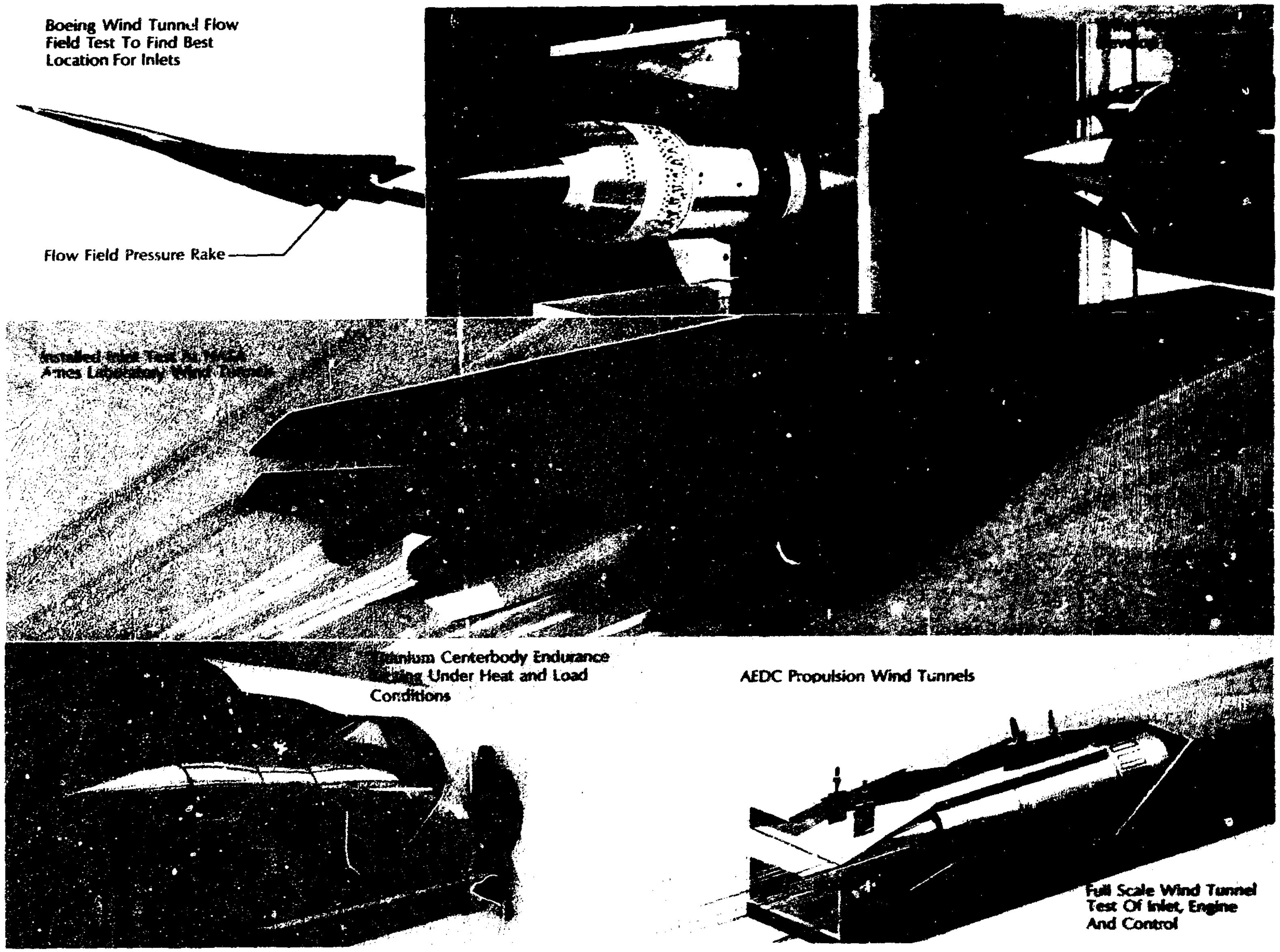
The Boeing inlet is the result of more than 15 years of intensive research and development. For this type of work Boeing has developed one of the finest privately owned inlet research facilities in the world. In addition to the Boeing wind tunnel facility, three supersonic wind tunnels and two subsonic tunnels in the propulsion laboratory have been used for inlet and inlet control development. Two of these supersonic tunnels have high rate variable Mach number and angle of attack capability for control dynamics testing. All have the capability to simulate gusts and sudden environmental changes so that the complete spectrum of normal and emergency flight conditions are explored. All three supersonic tunnels are now being used to further refine the SST inlet.

For example, tests of complete models of the inlet, with variable diameter centerbody and a simulation of the proposed control system, have successfully demonstrated the capability of the inlet to continue stable operation with high efficiency despite sudden Mach number changes or gusts. Tests of two operating inlets beneath a wing have assured that one inlet cannot adversely affect the other in any operating condition.

A full-scale, titanium, variable-diameter centerbody is now undergoing high temperature and pressure endurance testing to prove the structural and sealing concepts.

In late 1967 an airplane model with operating inlets will be tested in NASA wind tunnels to further verify the installed performance in the actual airplane flow environment.

In 1968 Boeing will conduct a full scale test in the Arnold Engineering Development Center Supersonic and Transonic wind tunnels (Tullahoma, Tenn.). The inlet, inlet control, and engine and engine control will be installed in the tunnel as on the B-2707 airplane. This test will demonstrate inlet/engine compatibility one and one-half years prior to the first flight of the B-2707.



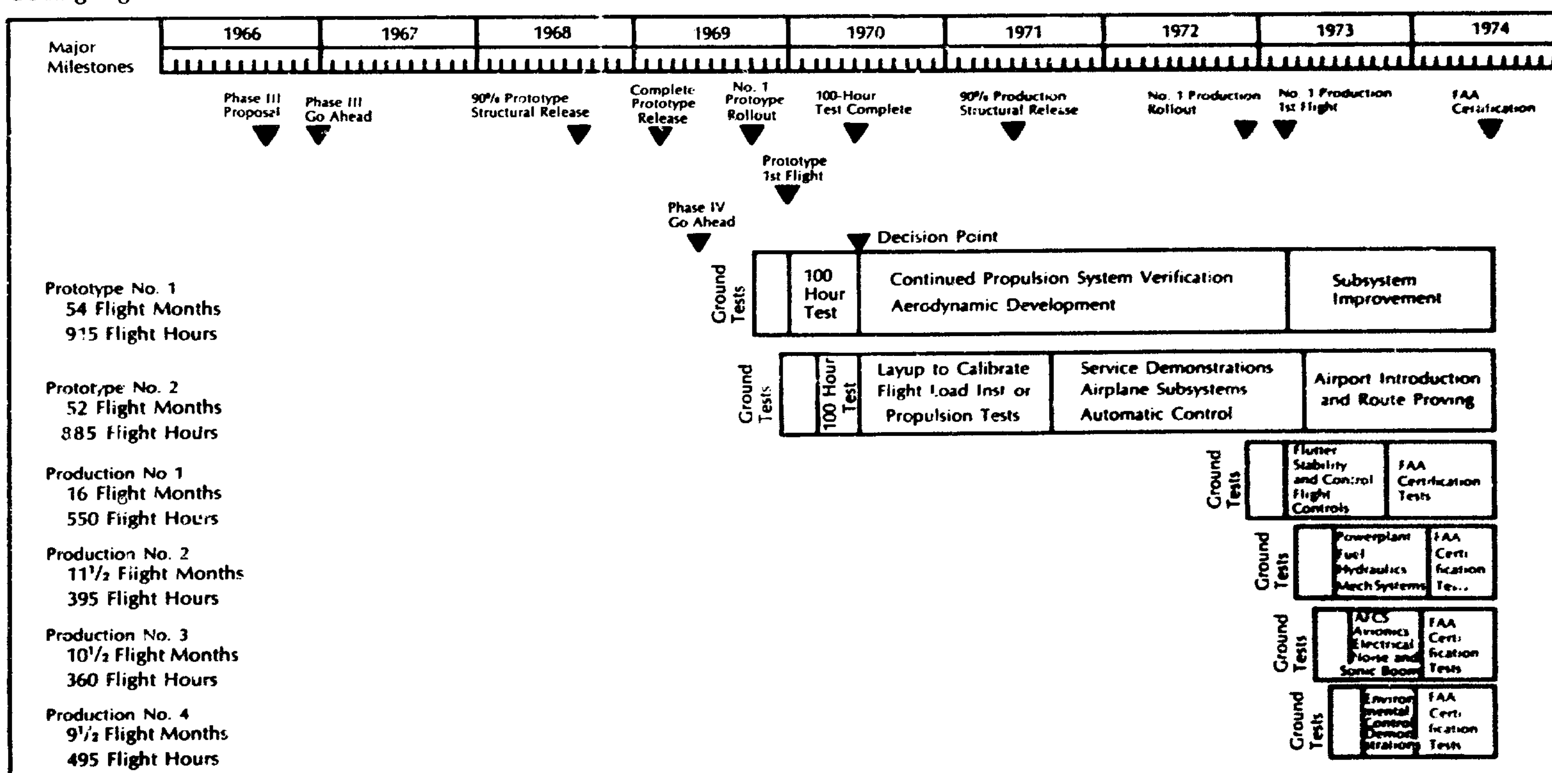
4·20 *Inlet Test*

FLIGHT TEST

The flight program is the final test in the development of the B-2707 as a safe, reliable, and economically profitable airplane. The Phase III 100-hour flight evaluation will be devoted to a comparison of actual versus predicted performance and characteristics, and will demonstrate the feasibility of the production airplane. Intensive testing during the first year of flight will permit the answers derived to be incorporated into the production design prior to drawing release.

The flight tests will be planned in detail for each flight. The Boeing flight simulator will be used to rehearse tests. Backup test plans will be developed to insure full utilization of each flight. Coordination with the engine manufacturers and suppliers to define test requirements initiated during Phase II-C will be continued in Phase III.

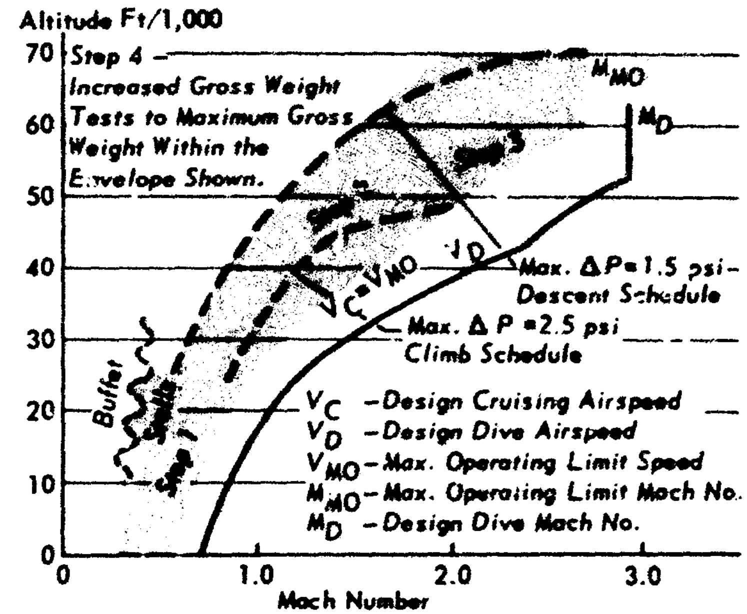
Boeing's extensive airplane test instrumentation and data systems have been the most advanced and are being further developed for the 737 and 747 programs. The data systems, originally developed for missile and space programs, were first used on the 707 in 1958. When fully developed, this system will have the capability of recording several thousand variables at a rate up to 1,000 channels per second.



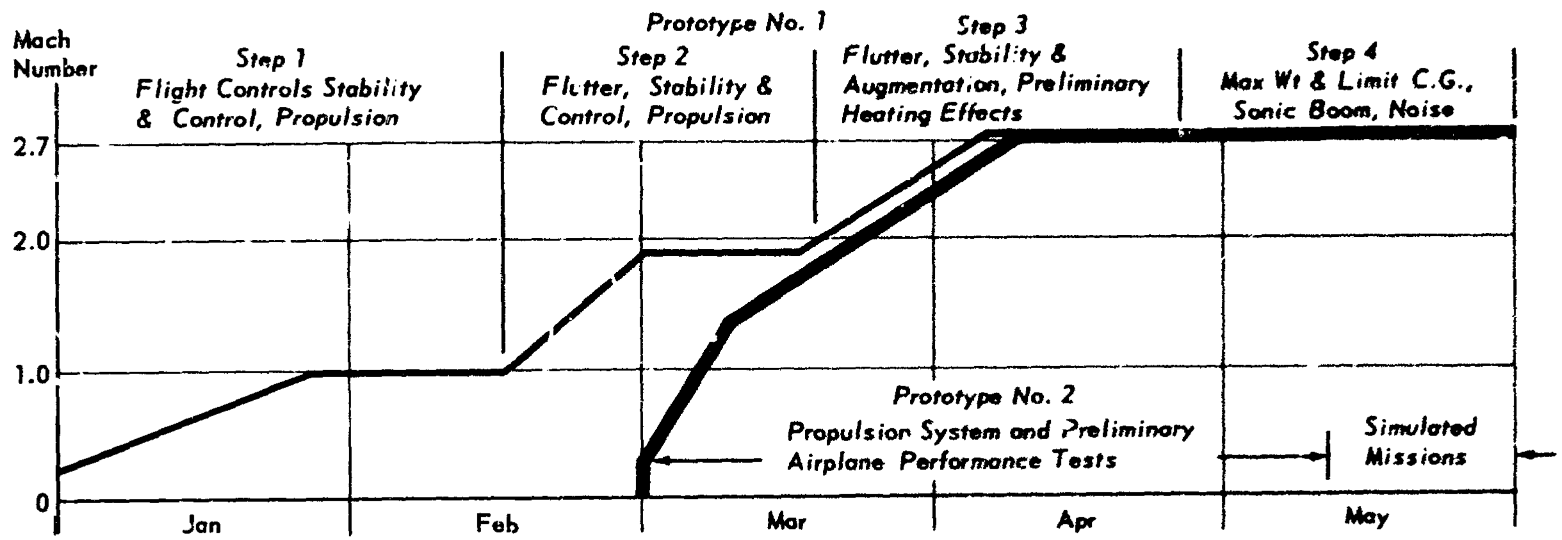
4·21 *B-2707 Flight Test Program Summary*

The SST data system will provide data displays with monitoring for test control, both onboard and telemetered; quick-look data for preliminary evaluation 2 hours after flight; and computer processed data for final engineering evaluation 12 hours after flight. Twenty-four hours after each test, summary reports will be available at Boeing-Seattle, NASA-Edwards, and the FAA. The data acquisition systems will never impose limitations on flight hours per month. The recording, computing, and editing of the critical data necessary to check safety and performance, will be programmed prior to each flight to permit quick and yet thorough analysis before proceeding with the next test.

Boeing policy is to develop the prototype in the wind tunnel and by other ground tests to the maximum capability of known analysis and test techniques before finalizing the design. This policy avoids excessive development of the system in the air. By utilizing the experience on all flying supersonic airplanes to the maximum extent, and by the most advanced analytical and ground test techniques, plus the most advanced flight test instrumentation, there will be high probability of completing the first 100-hour proto-



4·22 Phase III Envelope Expansion Steps



4·23 100-Hour Flight Test Program

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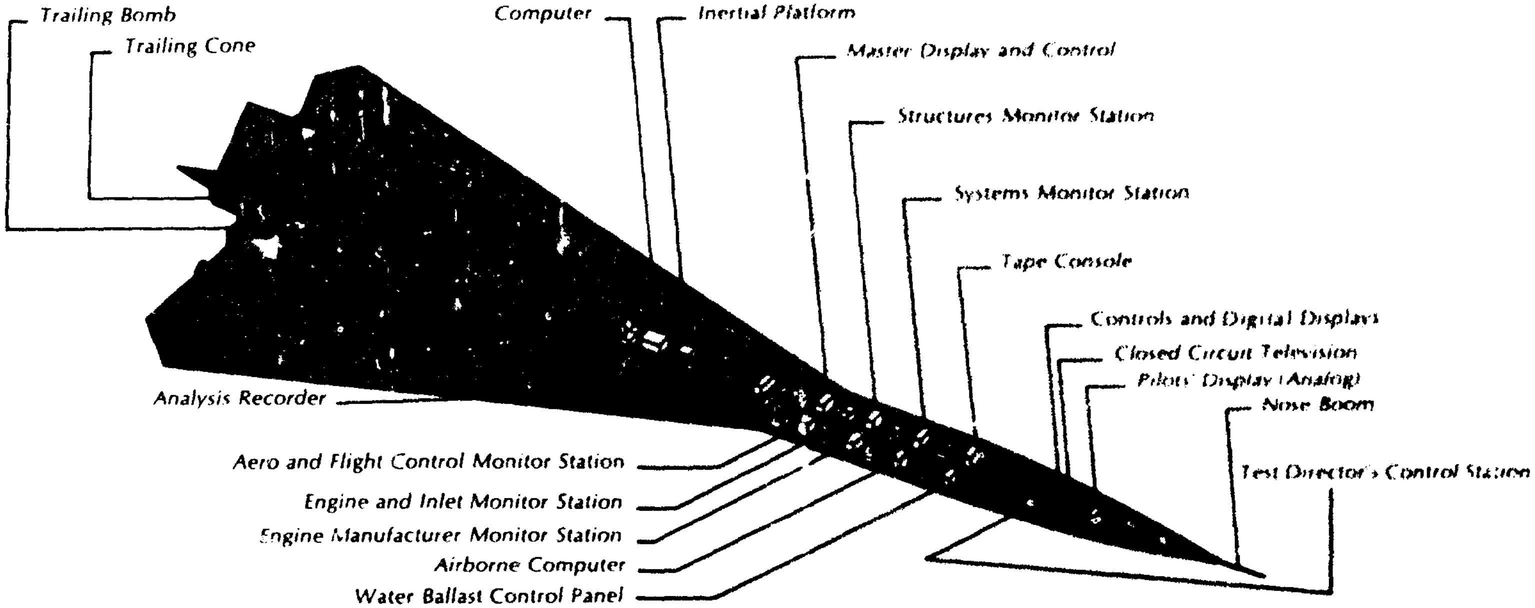

4•24 Flight Test Airborne Instrumentation

type flight test without any interruption for major changes. Boeing past experience has shown that test pilots can thus fly around most flight difficulties safely, and that any major changes desired can be postponed until the overall assessment is made.

The instrumentation used for laboratory, ground, and flight tests is being planned so that results of the programs can be correlated. In addition, Boeing proposes to take one or more of the engine manufacturer's ground test engines with essentially identical test stand instrumentation from which data has been obtained in the test cells and install it on one of the prototype test airplanes. A test station is provided for the test engine manufacturer's crew to monitor the instrumentation and observe tests. In this manner any differences in engine performance from test stand predictions will be determined early in the program. This will facilitate early assurance that the installation is favorable and that engine-air-frame compatibility is attained.

Examples of advanced instrumentation equipment being developed are the inertial reference systems and flight path accelerometers. This equipment could allow the use of advanced testing techniques to determine airplane drag from level flight acceleration and airplane stability from dynamic flight maneuvers. The flight loads program will utilize a combination of strain gages and pressure transducers such that calibration is achieved in a minimum time. Instrumentation will be installed during the prototype manufacturing cycle.

Edwards/Wendover test range is scheduled for measuring sonic boom overpressure. High gross weight, refused and abused takeoff, airspeed calibrations, and other tests where accurate tracking and airspeed measurements are a requirement, will be conducted at Edwards Air Force Base. Plans for an off-shore test range have been developed for high Mach number testing.

The B-2707 flight test program will insure certification to FAA standards on schedule.

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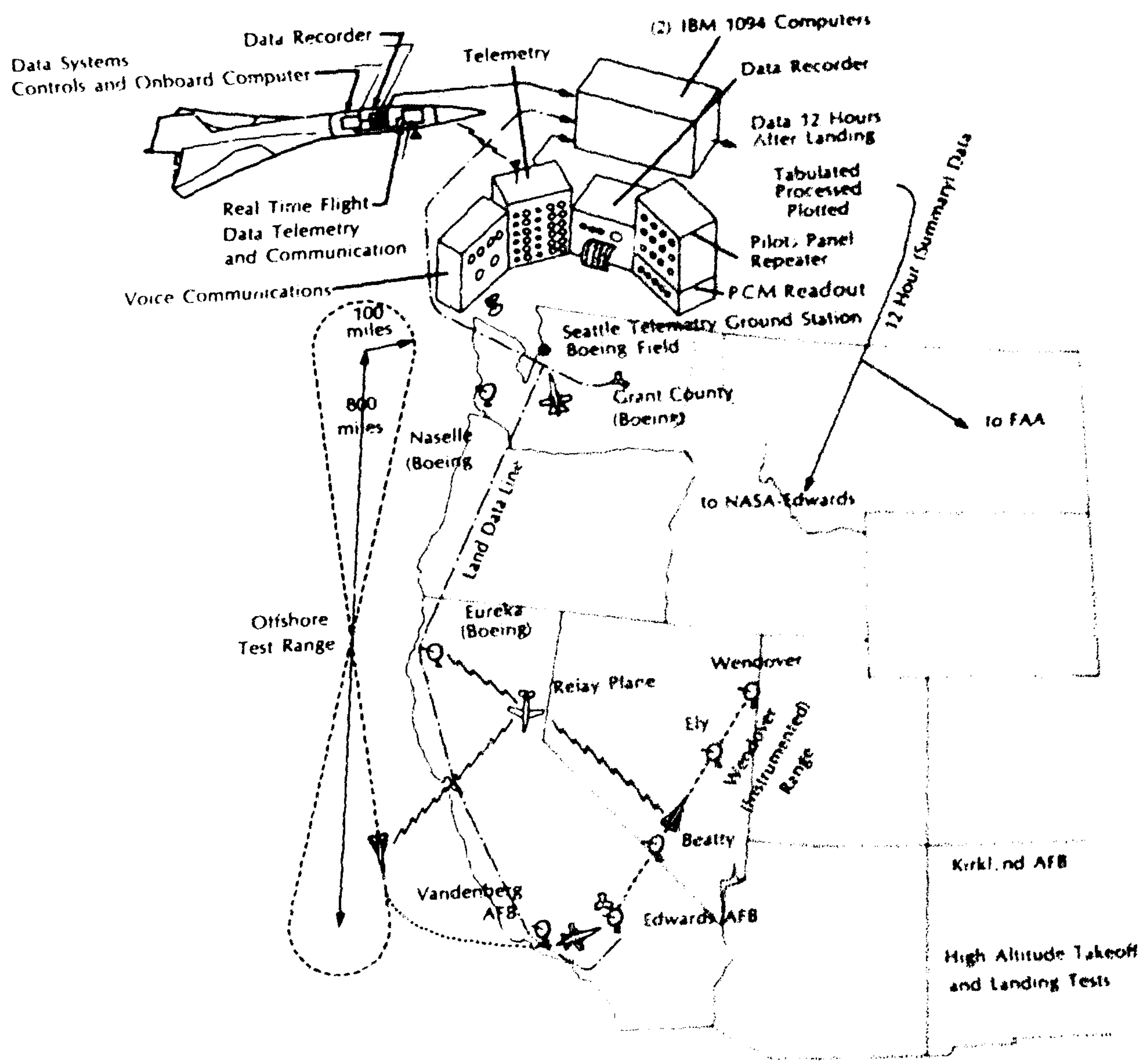


4·25 *Phase III Test Ranges and Instrumentation*

V1-B2707

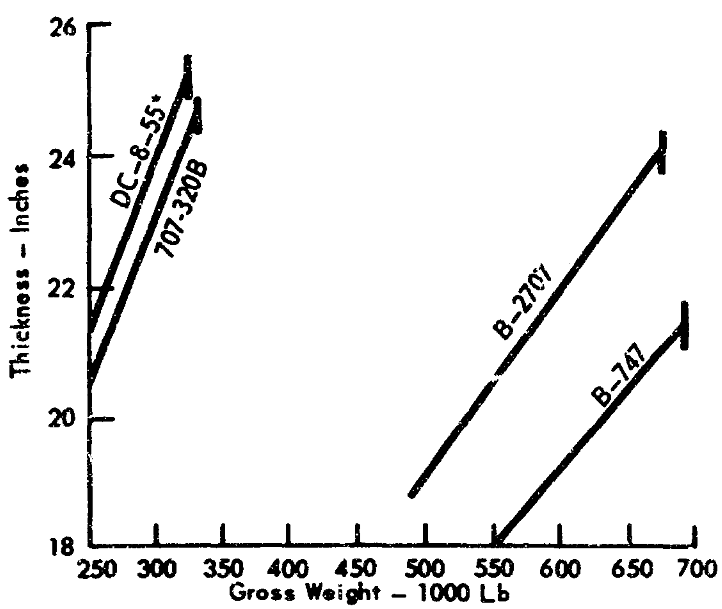
Ground Environment Compatibility

The B-2707 at a typical satellite terminal area is compatible with parallel, canted, or nose-in parking and generates no unusual terminal area maneuvering problems. The four passenger loading doors permit use of two adjoining gate positions, with up to four conventional jetways.

Studies of major U.S. airports confirm that the B-2707, with its multi-strut landing gear configuration, requires no major runway/taxiway pavement improvements.

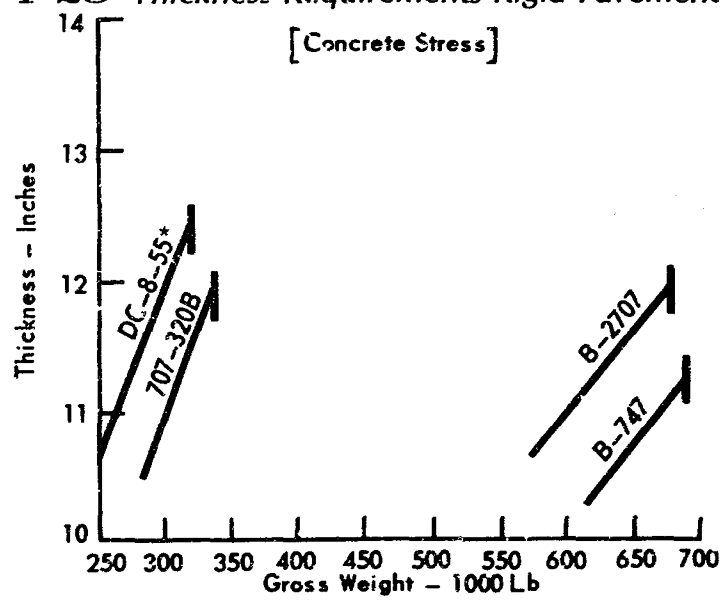
Approximately 70 percent of ground service equipment (GSE) requirements for the B-2707 can be satisfied by existing airline inventory with, at most, minor modifications. No new state-of-the-art service GSE will be required.

4•26 *Thickness Requirements Flexible Pavement*

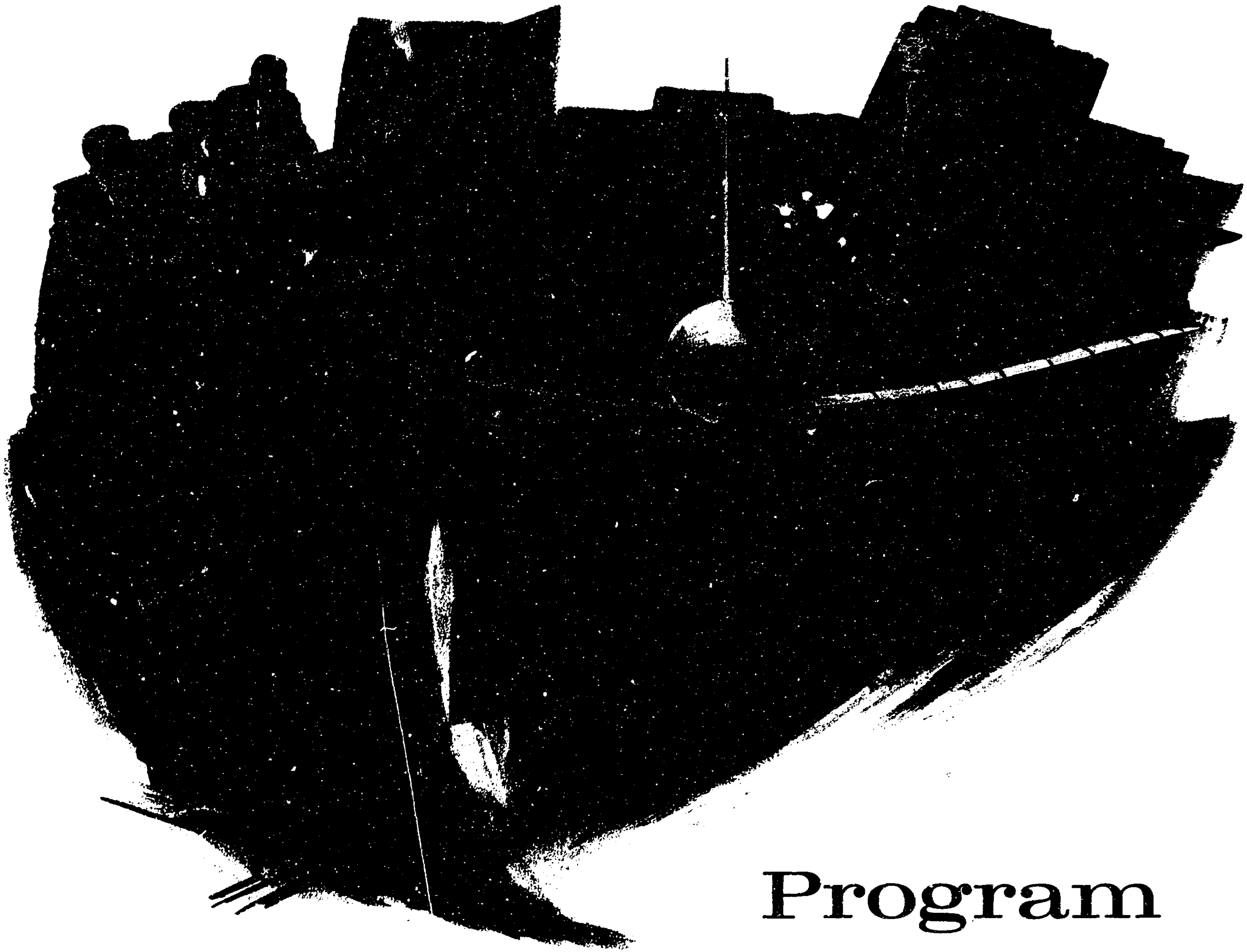


4•27 *Terminal Compatibility*

4•28 *Thickness Requirements Rigid Pavement*



*Airport Operators Council Reference Airplane



Program

RESOURCES

Boeing will make every effort to assure the success of the SST prototype program by providing required manpower, facilities, and financial resources. Use of these resources will be channeled and controlled by master schedules and comprehensive manufacturing plans.

To insure direct top management control, the SST Division has been formed and assigned the single mission of designing, developing, manufacturing, and testing the supersonic prototypes and subsequent production airplanes. Managers have been selected for their proven leadership and practical experience in the airplane industry. See Figs. 5-3 and 5-4.

Modern airplane developmental and manufacturing facilities have been provided at the Boeing Developmental Center in Seattle. The two prototypes will be constructed here and the first flight will be conducted at the adjacent Boeing Field. Government facilities will not be required, with the exception of specialized test facilities.

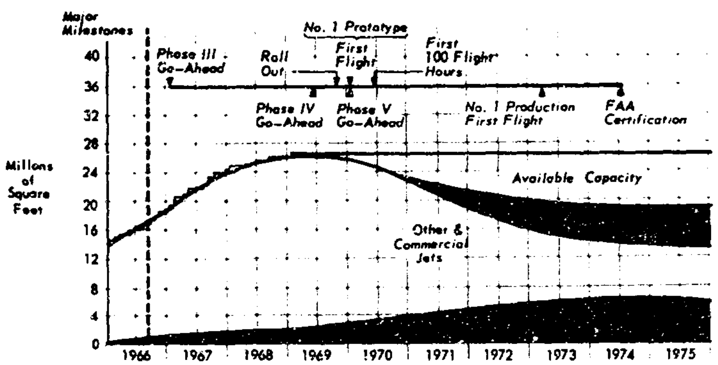
The limited size of the requirements of the planned prototype and production programs relative to the total facilities resources in the Seattle area is clearly illustrated in Fig. 5-1. Maximum facilities use at the peak of the prototype program is less than 10 percent of the total available in the Seattle area.

In response to the FAA Request for Proposal, Boeing has shown production facilities capacity for the manufacture of three supersonic transports per month. However, should the market develop to require it, facilities both current and under construction for existing commercial programs can be committed for the production of ten and one-half SST airplanes per month while continuing simultaneous production of subsonic jets.

People are The Boeing Company's most important asset, and as such they will be specially selected to meet requirements of the SST program. Definite commitments have been made for obtaining these personnel and plans have been developed for their utilization and motivation.

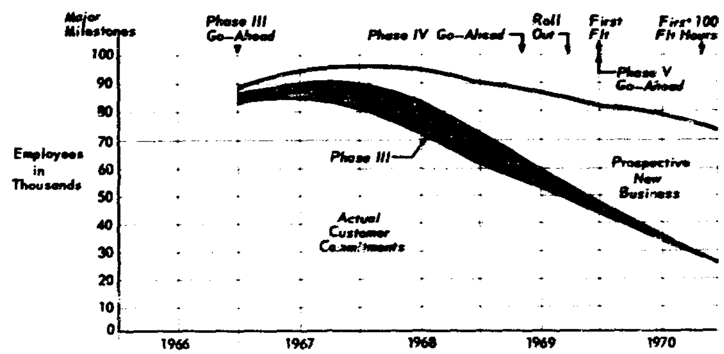
Critical skills are already assigned both on the SST program and on the other major programs planned for the Seattle area. Even at the peak, the SST Phase III requires only slightly more than 10 percent of both the technical and overall Boeing manpower in the Seattle area (Fig. 5-2).

5•1 *B-2707 Facilities Requirements Versus Available Seattle Area Capacity*



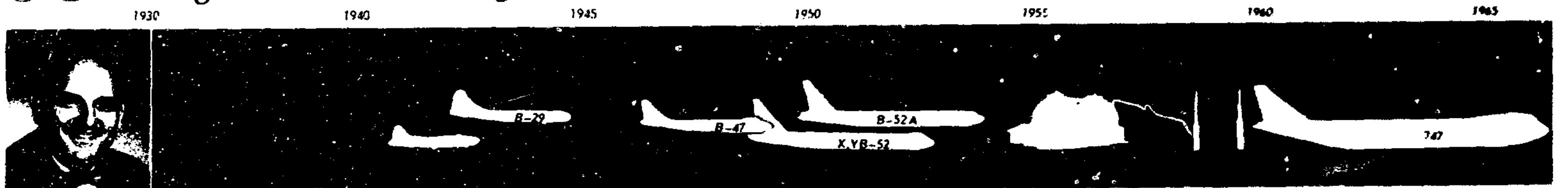
B-2707 Facilities Requirements vs Available Seattle Area Capacity

5•2 *Phase III Manpower Requirements Versus Total Seattle Area Manpower*

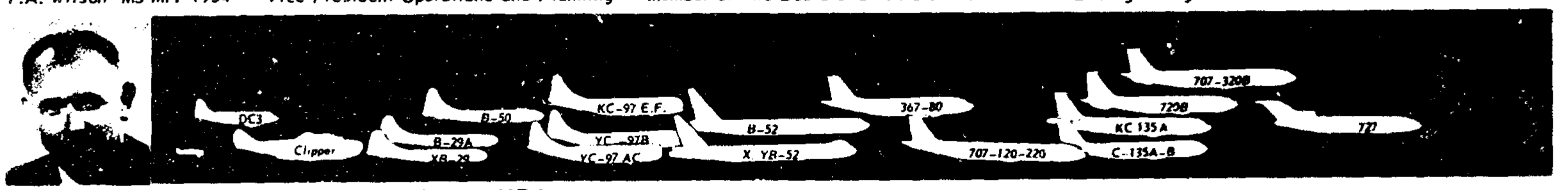


Total Seattle Area Manpower

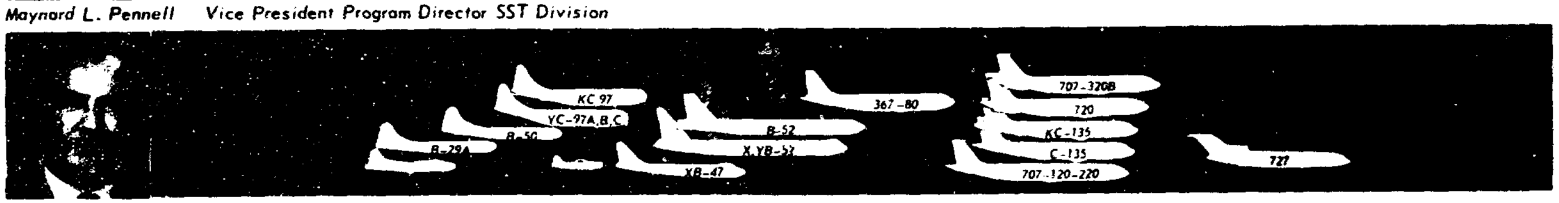
5·3 Boeing SST Division Managers



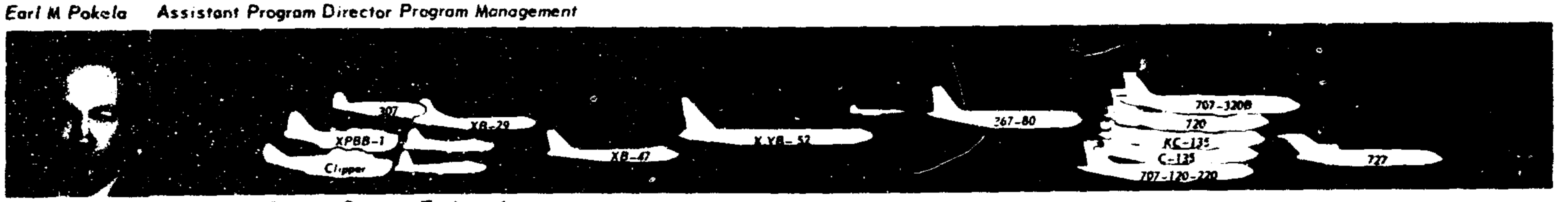
T.A. Wilson MS MIT 1954 Vice President Operations and Planning Member of The Board of Directors Chairman of Boeing Management Council



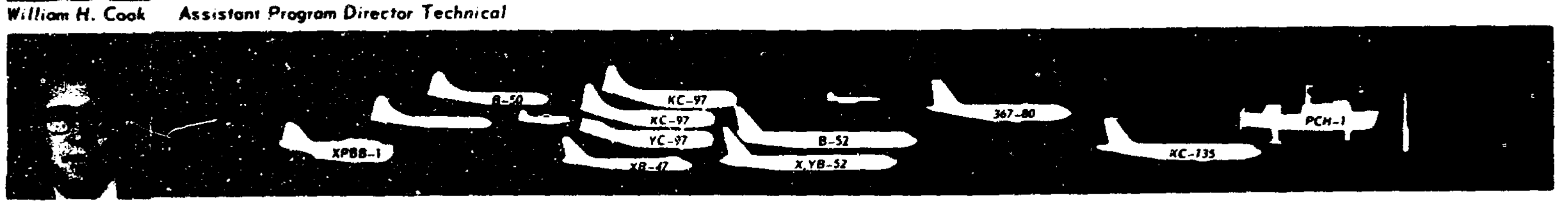
Maynard L. Pennell Vice President Program Director SST Division



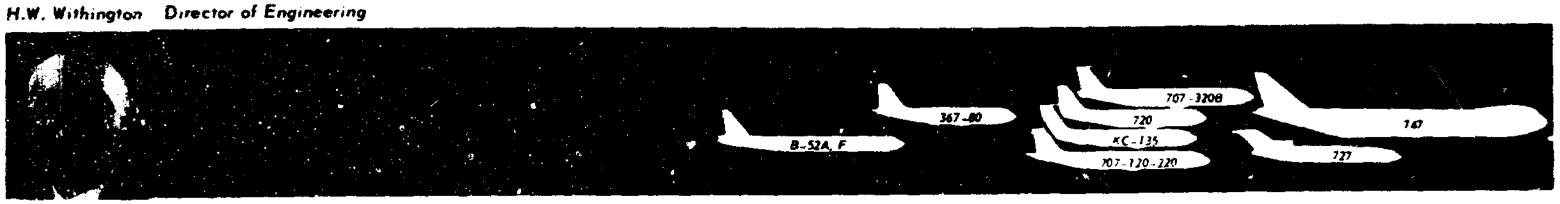
Earl M Pokela Assistant Program Director Program Management



William H. Cook Assistant Program Director Technical



H.W. Withington Director of Engineering



Fred M. Maxam Chief Engineer--SST Division

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5·4 *Boeing SST Division Managers (continued)*

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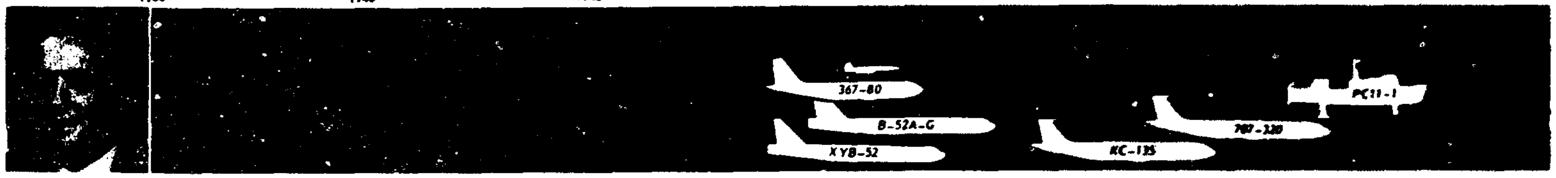
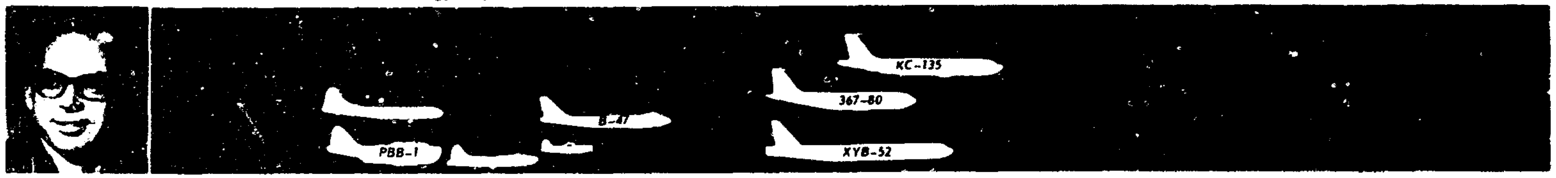
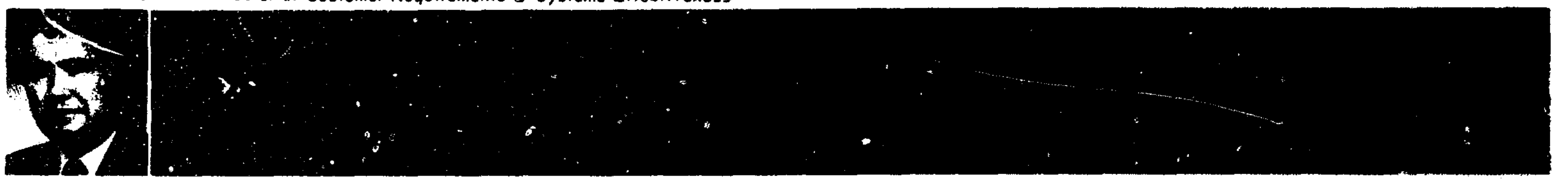


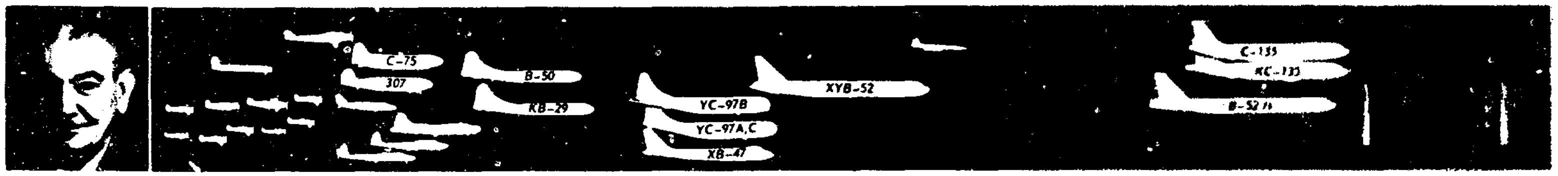
W.T. Hamilton — Chief Engineer–SST Technology Dept



L.T. Goodmanson — Director of Customer Requirements & Systems Effectiveness

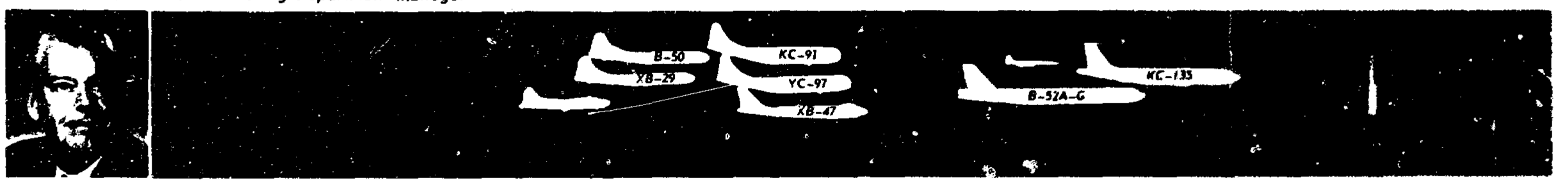


J.M. Swihart — Technology Integration Chief



H.E. Hurst — Director of Operations

J.H. Morrison — Manufacturing Department Manager

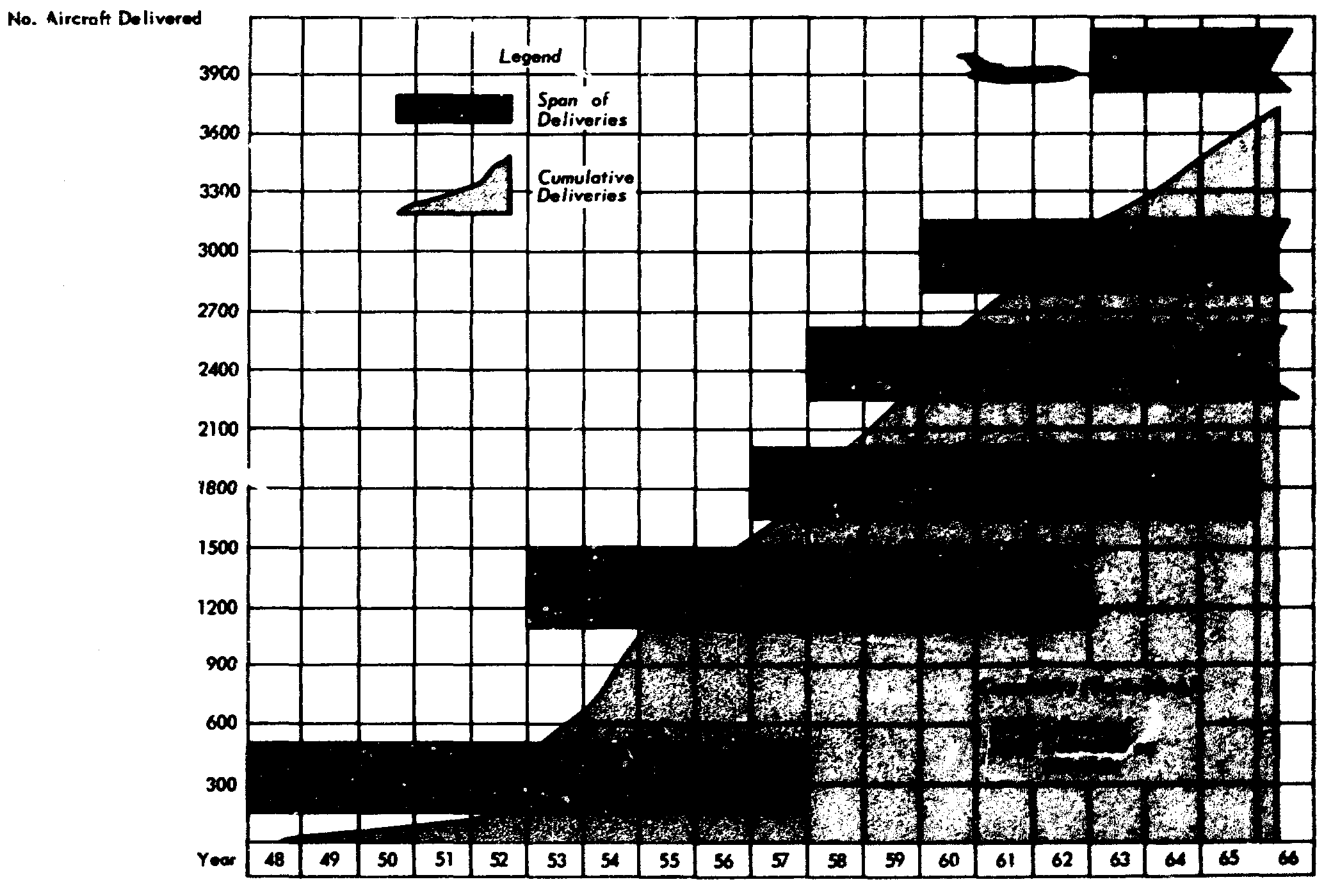


V.J. McCrohan — Director of Business Management

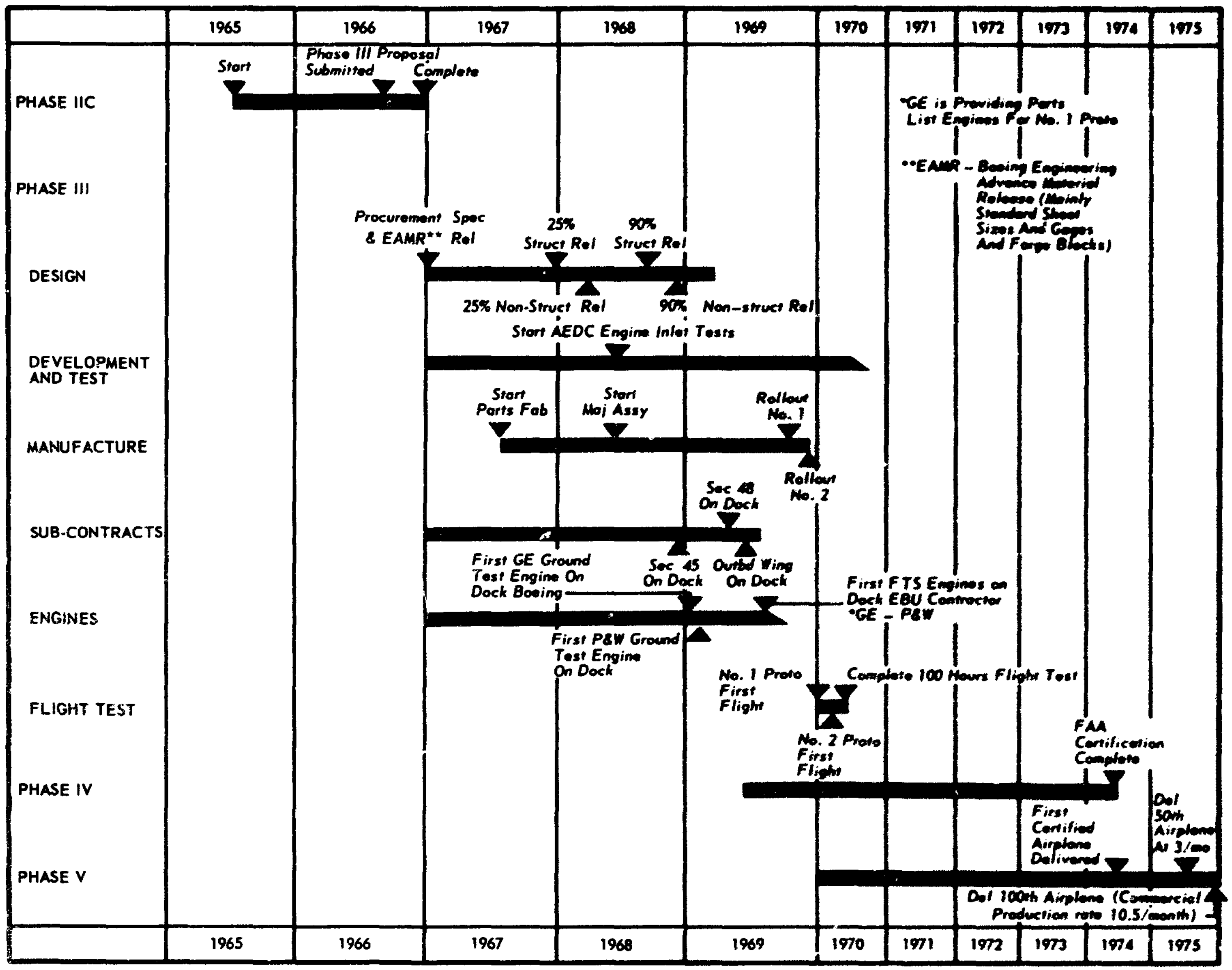
PROGRAM PLAN

The Phase III program schedule is realistic and achievable. The milestones of the Phase III program are shown on the SST Master Program Phasing Summary (Fig. 5-6).

Boeing has established an unmatched capability for delivering airplanes of advanced technology on schedule. As seen in Fig. 5-5 98.8 percent of the 3,681 jet airplanes constructed by Boeing since 1947 have been delivered on or ahead of schedule. During this same period four prototypes and seven number one production airplanes of different configurations were also produced. Of these, four airplanes were behind schedule (3 months 21 days maximum) and seven were ahead of schedule (one month maximum).



5•5 *Boeing Schedule Competence*



5·6 SST Master Program Phasing Summary

MANUFACTURING

The manufacturing program for the B-2707 is structured to produce two prototype airplanes for flight testing on schedule at minimum cost while establishing a base for manufacturing production airplanes.

SST manufacturing and operations will be concentrated at Boeing's Developmental Center. A portion of the fabrication, tooling, and processing activities, the majority of manufacturing research and development, and all of the inplant sub-, major, and final assembly operations will be accomplished here. Conventional manufacturing techniques, proven in commercial use, will be used throughout both prototype and production phases.

The tooling policy for the Boeing SST prototype program limits the building of tooling, dies, fixtures, jigs, etc., to only those necessary to produce two airplanes meeting design requirements.

Numerically controlled machines can make identical detail parts without specialized tooling. Hot form dies used to form titanium parts for the prototype will be identical to the production tools except in the number of units required.

Major assembly jigs and fixtures will be the same for both prototype and production except that the prototype tools will have sufficient additional locators so that subassembly tooling will not be needed. Subassembly tools will be added for quantity runs for the production model.

The benefits of this concept are:

Minimum prototype tooling expenditures consistent with quality

Maximum use of this prototype tooling in the production program ensures a low waste factor and shorter production flow times

Experience gained from the prototype tooling and manufacturing programs will produce higher quality tooling at lower cost and reduce the production tooling flow time requirements

Earlier first flight for the prototypes is possible because of the short flow times required for minimum tooling.

5•7 *Titanium Sheet Stretch Form Die Heated with Quartz Lamps used for Prototype and Production*

V1-B2707-1

Assembly

The B-2707's major sections will be built in assembly tools called section docks and will employ mechanical fasteners for the basic structure. The fuselage has six major sections. Body structures are comprised mainly of skins, stringers, frames and floor beams similar to present commercial airplanes. These components will be panelized, built into lobes and joined into major body sections.

The center wing and outboard wings are of a machined skin, stringer, spar and inspar rib construction. These structures will be manufactured by assembling upper and lower panel assemblies, front and rear spars and the inspar rib assemblies. The forward inboard wing is similar in construction except the upper and lower panels are bonded polyimide honeycomb construction. These panels will be mechanically fastened to the spars and ribs.

5•8 *Assembly Sequence*

MASTER DIMENSIONS AND NUMERICAL CONTROL

Master dimensions and numerical control are standard procedures in the Boeing engineering design and manufacture of airplanes. The entire surface of the airplane is mathematically defined by a computer system using basic central points from engineering drawings. A three-dimensional definition is evolved and stored.

From the stored data engineers can obtain drawings of planar cuts automatically from numerically controlled drafting machines. Allowances for skin thickness are automatically deduced to obtain contours for adjacent interior parts.

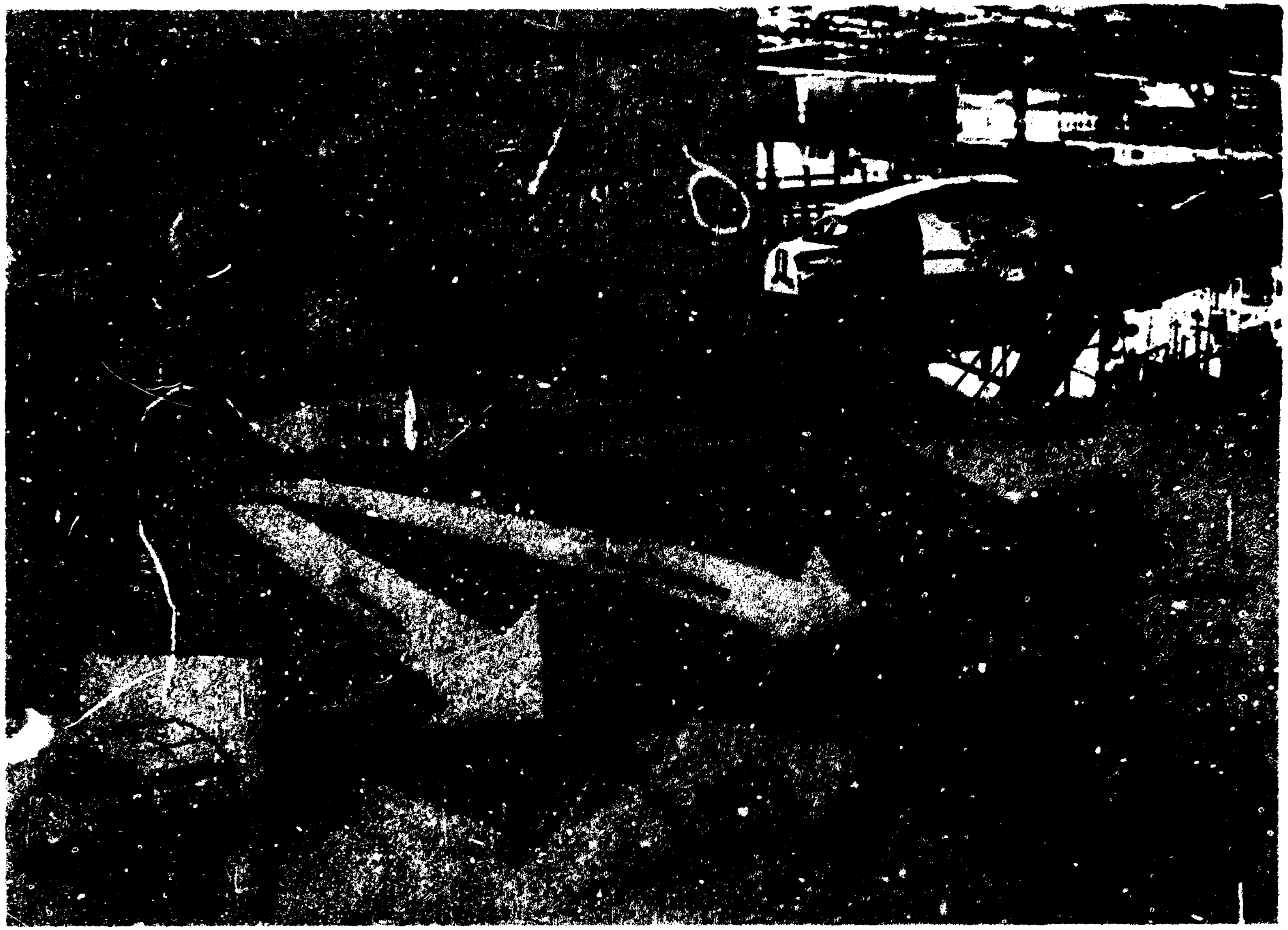
The engineer continues the process as bulkheads, stringers, stiffeners, and even rivet holes are designed and placed with the assistance of the master dimensions computer programs. The resultant stored/retrievable data is the authoritative source of all dimensional data. This data is distributed by Boeing to each subcontractor for dimensional control of all parts and assemblies.

The finished parts, assemblies and associated drawings are produced from identical sources of computer-accurate data. This single source data is also used to drive numerically controlled manufacturing machines such as multi-axis milling machines, riveters, spot welders, and routers. Dimensional data is immediately accessible for quality control verification. The final result is a manufacturing assembly that proceeds with maximum efficiency as parts fit together without adjustment.

Boeing is the first company to define the surface and adjacent interior parts of the entire airplane mathematically. An example of the practical use of master dimensions and numerical control is indicated by the reductions in the number of shims required to join major body sections.

Sev... ...ndred shims were required on the 707-120 series airplanes in order to join sections which were not computer controlled. The 727 which was mathematically defined but not entirely numerically controlled required 134 shims. The latest ...eing airplane, the 737, having the same dimensional size but completely master dimensioned and numerically controlled required only two shims to join the sections.

5•9 *Boeing Master Dimension and Numerical Control Application*



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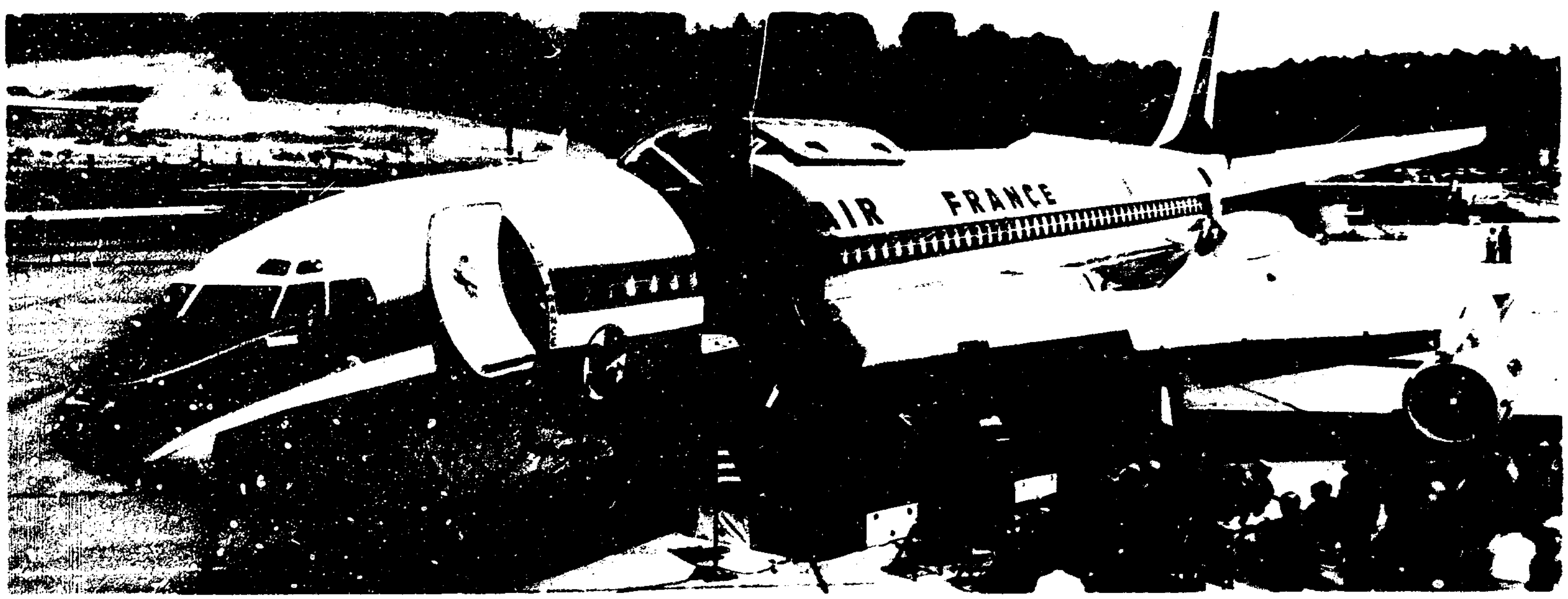
CONFIGURATION AND PRODUCTION CONTROL

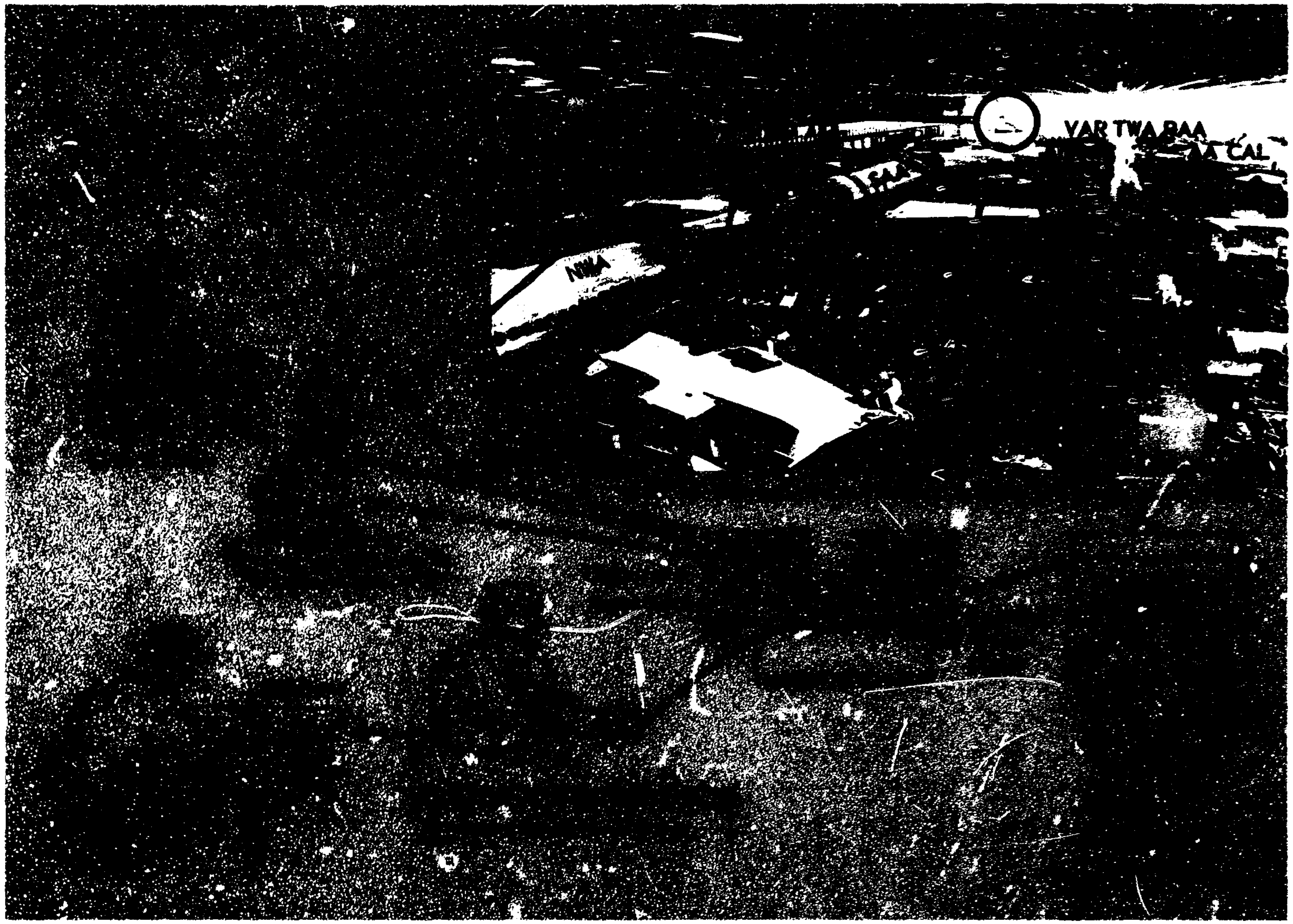
The Boeing configuration and production control systems are supported by the most extensive computer applications in industry. This complex of integrated computer programs spans the production cycle from the automated design release through airplane certification. These programs permit immediate visibility of in-plant and subcontractor production status, i.e., material, parts, assemblies; orders, inventories, disbursements, schedules; resource requirements; manpower, machines, etc. Programs also process instructions on which tools to use, material required, where to get it, how to machine it, how to inspect, and where to send the part. Linked with the Production Control Systems is a complex of business management systems that electronically compile accounting records and allow management to determine the detail cost of parts and assemblies for budget/cost control.

To meet commercial program requirements, Boeing has developed the most dynamic airplane Configuration and Production Control system in the world, handling 2,740,000 parts per month consisting of 325,000 distinct part numbers. This system has the flexibility of handling either prototype or production programs. Boeing's commercial airplane production line, which features 4 basic models, 21 engine configurations, 9 body lengths, 10 wing configurations, and 113 different customer configurations, is in reality a very large scale but carefully monitored specialty manufacturing operation. This same highly successful system is readily adaptable to large scale prototype operation of the type required for Phase III.



5·10 *Formal Customer Acceptance of a Boeing Quality Control and FAA Certified Airplane... Picture Taken at The Boeing Commercial Delivery Center Located on Boeing Field Adjacent to The Developmental Center*

5•11 *Boeing Multi-Customer, Multi-Model Airplane Configuration and Production Control*



Titanium Manufacturing

The Boeing Company and its subcontracting team is capable of manufacturing—with minimum developmental risk—a titanium alloy SST. Boeing pioneered titanium structure and parts as long ago as 1951.

Present production experience plus the methods and procedures developed in a long-continuing manufacturing research program provide a sound basis for the B-2707 prototype program.

During the last three years Boeing has expended more than $5 million of manufacturing research funds on more than 500 titanium research projects and has completely documented some 70 production-oriented processes. Currently, an average of more than 16,000 pounds of finished titanium assemblies per month are being used in Boeing missile and airplane production. The B-2707 prototype is expected to use an average of 14,490 finished pounds per month (Fig. 5-12).

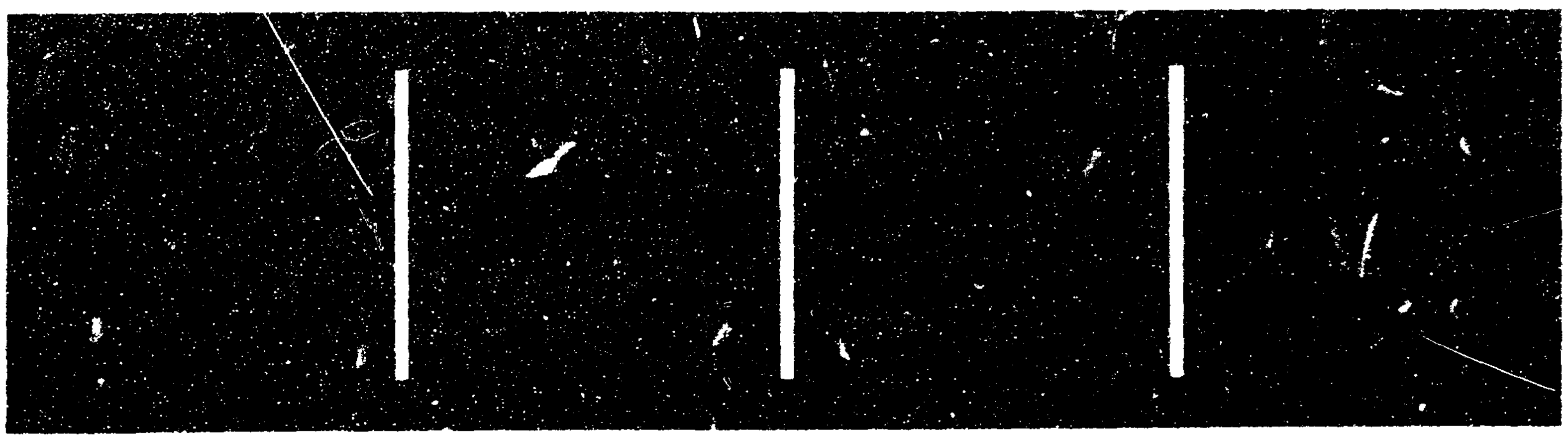
Full-size SST body and wing assemblies have already been fabricated and other items are in production. Through the application of proven design and manufacturing techniques the cost of these items compares well with the cost of aluminum fabrication.

Boeing has developed titanium alloy machining and drilling techniques to a high degree of proficiency. Numerically controlled milling is accomplished at speeds comparable to those applicable to steel.

Spar milling feed rate is now approximately 15 times that of two and a half years ago, and tool life has been increased to 25 times its former duration. Face milling tool life has increased to three or four times that formerly achieved, and the metal removal rate is now from two to four times that previously experienced.

Metal removal rates by chemical milling are now the same for titanium alloys as for aluminum—0.001 inch/side/minute. Surface finishes are excellent and an RHR between 15 and 30 is routinely attainable.

5•12 *Boeing Titanium Utilization*



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Drilling rates have been increased two to three times over previous rates, during the last two years because of improved techniques and newly developed drills.

A combination drill reamer and countersink tool has been developed especially for the drilling of close tolerance holes in titanium. These three functions are now performed economically and quickly with a single tool in one operation.

Advances made in hot forming techniques include net cast hot size forming tools which produce net shape parts. These net size parts contribute to fast, accurate assembly. Boeing has also developed a new concept of elevated temperature vacuum forming on single faced tools that effects appreciable savings.

Boeing is the acknowledged industry leader in the development and application of polyimide bonded titanium and fiberglass honeycomb aircraft structures, which cost less to make than composite structures requiring conventional fabrication techniques.

Computer control techniques employed in some production processes (such as metal cleaning, metal-to-metal bonding, and polyimide bonding and curing) minimize process deviations, thereby improving efficiency and lowering costs.

Boeing's major titanium processing facility is located at the Developmental Center adjacent to the high bay final assembly area. Titanium parts can make the journey from fabrication to final assembly in less than five minutes.

5•13 Boeing Titanium Milling Rates

*6 inch diameter, C-1 carbide milling cutter; depth of cut .050 inch or less. 200 SFPM and 0.017 IPT.

**With 12 inch diameter 36 tooth carbide insert face mill operating. 130 SFPM, 130 SFPM, 0.065 IPT, and 0.125 depth of cut.

FACILITIES

Boeing will design, develop, assemble and test the SST prototype at the Developmental Center. This 108-acre site contains more than 36 acres of covered space that provides a balance of closely related manufacturing, laboratory, storage and office facilities that are essential to accomplishment of the prototype program.

The Developmental Center was designed and built in 1958 to support prototype airplane development and was subsequently used in development of the Company's missile product line. These activities have resulted in a continuous upgrading of facilities to support advanced technologies; these facilities are ideal for the SST prototype program.

The SST Division was relocated to the Developmental Center in March, 1965, and has grown steadily until it now occupies one-third of the site. The SST prototype program, at peak requirements, will occupy more than 90 percent of the Center.

The Developmental Center and its related laboratories and test facilities, in conjunction with adjacent Boeing Field with its 10,000 foot runway, offers an integrated prototype engineering manufacturing airfield complex unique in the industry.

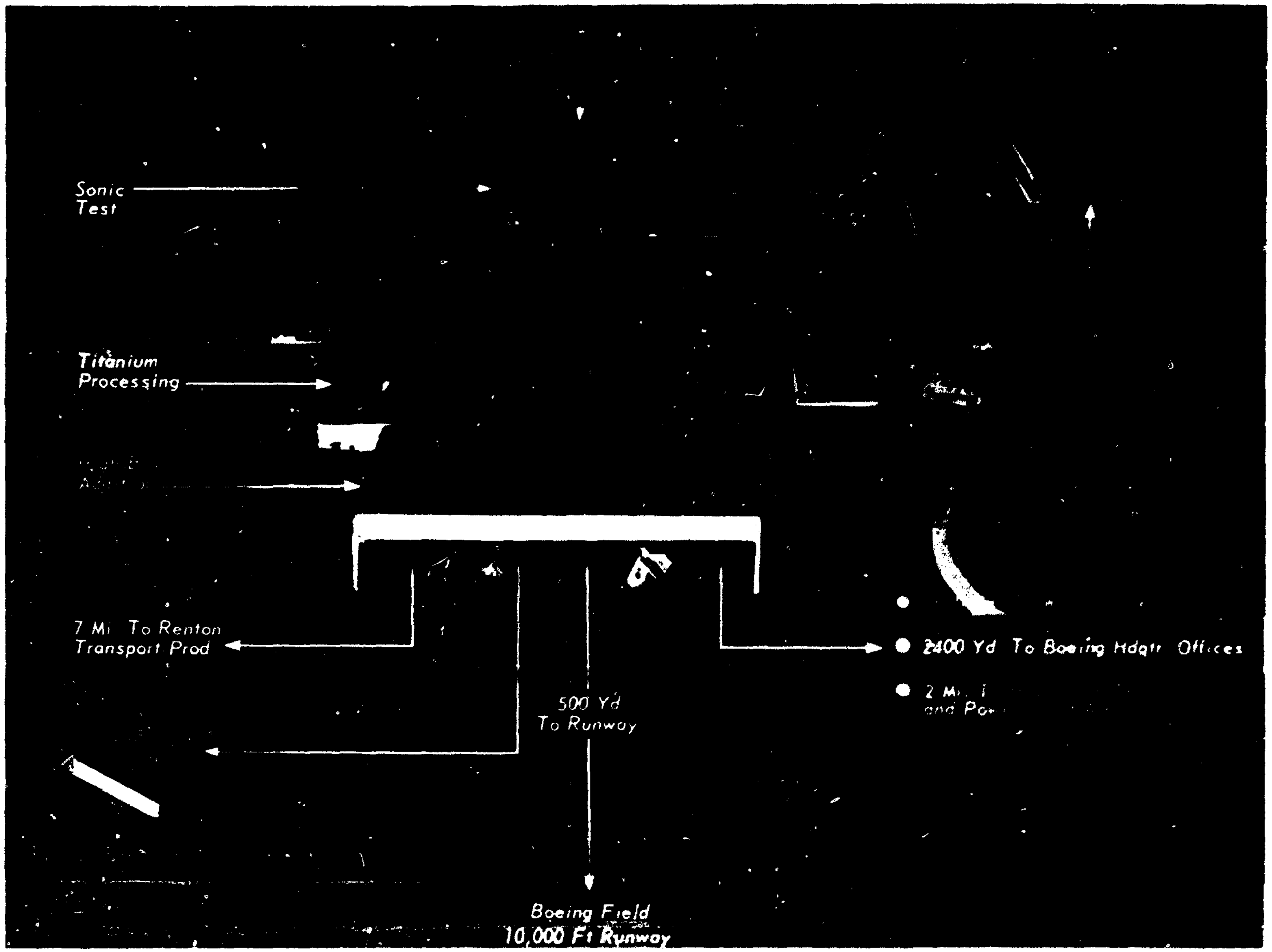
Equipment capability to support SST technology has steadily increased since 1965. Currently being completed at the Developmental Center is a Titanium Processing Facility addition encompassing 86,000 square feet of covered area and including chemical processing tanks capable of dipping panels 70 feet by 10 feet; five hot sizing presses that can handle panels up to 4 feet by 14 feet; a 70-foot by 10-foot stress relieving furnace and associated supporting equipment. The Titanium Processing Facility has been integrated closely with the adjacent fabrication and assembly areas.

The Developmental Center structures laboratory contains a *six* million pound structural slab and strongback and an integrated radiant heat facility. The structures laboratory is the hub of a consolidated grouping of SST Program Laboratories that will include a Materials and Process Laboratory, electrical, and electro/dynamic laboratories. In addition, a SST Flight Controls Servo Simulator facility will be constructed at the Developmental Center in 1967 to complete the SST Program Laboratories. Other support laboratories located adjacent to Boeing Field include the Boeing wind tunnels which make up the largest privately owned wind tunnel complex in the industry.

The company's new $110 million central fabrication facility, at Auburn, will provide general fabrication support. This concentration of spar and skin mills, process assembly fabrication, numerically controlled machine tools and tool fabrication equipment provides a fabrication resource base sufficient to support all Seattle area product lines. Operation at the site began early this year and has been increasing steadily; approximately 5,000 employees will be located on the site by year-end and 8,000 by mid-1967. This efficient and productive multi-project facility will be available to support the SST prototype phase, as well as production follow-on.

All the facility resources to be applied to the program in Seattle will be Boeing-owned. The new facility additions which will be funded by Boeing total $34,095,000 for Phase III of which $13,-765,000 has already been committed to ensure the timely availability of facilities.

5 • 14 *Boeing Developmental Center, Seattle, Washington*



INDUSTRY SUPPORT

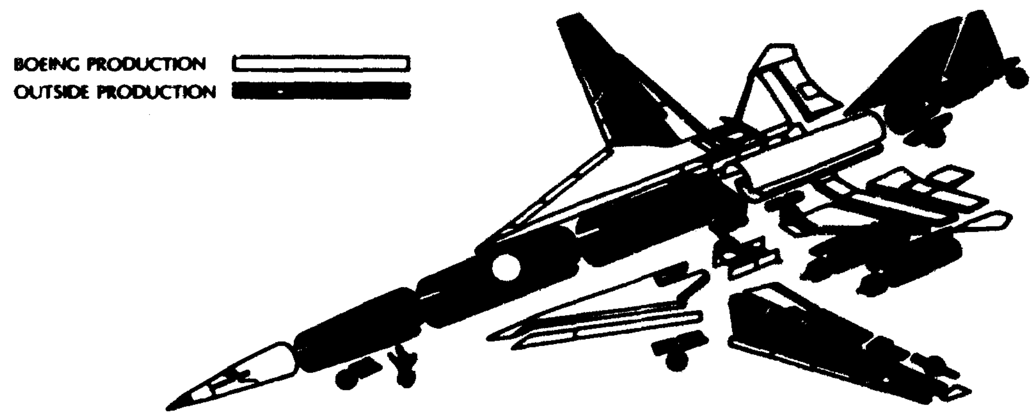
The Boeing Company, recognizing the total requirements and the national aspect of the SST Program, has established a strong Boeing-Industry production team for the prototype airplane. The same team is available to extend directly into the production phase. The selection of the members of this nation-wide team was based on each company's long-range resource capability in terms of man-power, technical know-how, facilities, and finances. Boeing has entered into signed agreements with each of these companies and they in turn have committed adequate resources to support the Phase III program. The procurement plan provides for the sub-contract of approximately 55 percent of the manufacturing effort and 70 percent of Airframe Manufacturer's Progress Report (AMPR) weight of both prototype and production programs.

Boeing has also established a potential supplier's base for sub-systems, equipment, and materials through extensive source re-search and the procurement of substantial Phase II-C development efforts.

Titanium is the major raw material requirement and the titanium industry demonstrated during Phase II-C their ability to support Phase III with the raw materials and fasteners. All these sources represent a major segment of the nation's industrial base with firms located in widely distributed areas of the country.

The Boeing-Industry team, through its wide diversification and combined resource capabilities, provides the flexibility necessary to absorb development or administrative changes inherent in a prototype program of the magnitude of the supersonic transport.

5•15 *Subcontracting Distribution—Major Components*



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5·16 *B-2707 Subcontractor Geographic Distribution*

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Potential Suppliers

ABEX Corporation	Oxnard, California	E
ABEX Industries of Canada, Ltd.	Montreal, Canada	E
AC Electronics Division	Milwaukee, Wisconsin	E
Aerojet-General Corporation	Sacramento, California	P
AiResearch Manufacturing Co	Los Angeles, California	E
	Phoenix, Arizona	E
American Cyanamid Co.	Havre DeGrace, Maryland	N
ARMETCO	Worcester, Ohio	T
Astro Met.	Worcester, Ohio	T
Automation Industries	Abilene, Texas	M
AVCO Corporation	Nashville, Tennessee	A
The Bendix Corporation	Teterboro, New Jersey	E
	North Hollywood, California	F
	South Bend, Indiana	L
	Baltimore, Maryland	E
Bertea Products	Pasadena, California	E
Blades Manufacturing	Rector, Arkansas	M
Blanchat Machine Co.	Wichita, Kansas	M
A. B. Boyd	Portland, Oregon	N
Brunswick Corporation	Marion, Virginia	E
Carlton Forge Works	Paramount, California	T
Carpenter Steel	San Diego, California	T
Cleveland Pneumatic Tool Company	Cleveland, Ohio	E
Coast Manufacturing and Supply	Livermore, California	N
Comet Tool & Die	St. Louis, Missouri	M
Coors Porcelain	Golden, Colorado	N
Corning Glass Works	Corning, New York	N
Crucible Steel Company	Midland, Pennsylvania	T
Curtiss-Wright	Buffalo, New York	T
Curtiss-Wright	Caldwell, New Jersey	E
Dependable Kellering	Livonia, Michigan	M
Dow Corning	Elizabethtown, Kentucky	N
Fairchild Hiller, Republic	Farmingdale, New York	A
General Electric Corporation	Waynesboro, Virginia	E
General Tire and Rubber Company	Akron, Ohio	E
Glassrock Products	Atlanta, Georgia	N
B. F. Goodrich Company	Akron, Ohio	E
Goodyear Tire and Rubber Company	Akron, Ohio	E
Hamilton-Standard Division	Windsor Locks, Connecticut	E
H. M. Harper	Morton Grove, Illinois	T
Harvey Aluminum	Torrence, California	T
A. W. Hecker	Atlanta, Georgia	M
Howitt-Robins, Ind., Foot Bros.	Chicago, Illinois	E
Hexcel Products Inc.	Berkeley, California	N
Honeywell, Inc.	Minneapolis, Minnesota	E
Howmet Corporation, Misco Div.	Whiteall, Michigan	T
Hydraulic Research & Manufacturing Co.	Burbank, California	E
Hydro-Aire Division, The Crane Corp.	Burbank, California	E
International Business Machines Corp.	Owego, New York	E
Kanarr Corporation	Kingston, Pennsylvania	M
Kelsey-Hayes Company	Springfield, Ohio	E
Kollsman Instrument Company	Elmhurst, New York	E

Ladish Company	Cudahy, Wisconsin	T
Lafiell Mfg. Co	Santa Fe Springs, California	T
Lear-Siegler Inc	Cleveland, Ohio	E
Libby-Owens-Ford Glass Company	Toledo, Ohio	E
Litton Industries, Inc	Woodland Hills, California	E
Loud Company	Pomona, California	L
LTV Aerospace Corporation	Dallas, Texas	A
The Marquardt Corporation	Van Nuys, California	E
The Martin Company	Baltimore, Maryland	A
Monsanto Company	St. Louis, Missouri	N
Moog, Inc	East Aurora, New York	F
Motorola, Incorporated	Scottsdale, Arizona	E
Murdock Machine & Engr. Co.	Irving, Texas	M
North American Aviation, Inc	Los Angeles, California	A
Northrop Corporation	Hawthorne, California	A
	Palos Verdes, California	L
Nuclear Metals	West Concord, Massachusetts	T
Pittsburgh Plate Glass Company	Pittsburgh, Pennsylvania	E
Precision Castparts Corp.	Portland, Oregon	T
Radio Corp. of America	Los Angeles, California	E
R & D Metals	Kidron, Ohio	T
Raybestos, Manhattan	Charleston, South Carolina	N
Reactive Metals, Inc	Niles, Ohio	T
Reisner Metals, Inc	Southgate, California	T
Rohr Corporation	Chula Vista, California	P
Royal Industries, Inc	Pasadena, California	E
Sargent Engineering	Huntington Park, California	E
Simonds Precision Products, Inc	Tarrytown, New York	E
Sperry Phoenix Company	Phoenix, Arizona	E
Steel Improvement & Forge Co	Cleveland, Ohio	T
Sundstrand Corporation	Rockford, Illinois	E
H. I. Thompson Fibre Glass Co	Gardena, California	N
Titanium Metals Corp of America	Toronto, Ohio	T
TRW, Incorporated	Cleveland, Ohio	E
Vickers, Inc	Troy, Michigan	E
Viking Forge & Steel Co.	Albany, California	T
Western Gear Corporation	Lynwood, California	E
Western Pneumatic	Kirkland, Washington	T
Weston Hydraulics	Van Nuys, California	E
Whittaker, Corporation	Chatsworth, California	E
Wolverine Tube	Allen Park, Michigan	T
World Tool & Engineering	Minneapolis, Minnesota	M
Wyman-Gordon Co	Worcester, Massachusetts	T

E – Equipment
L – Landing Gear
A – Airframe
P – Power Package
M – Machine Parts
N – Nonmetals
T – Titanium Products

V1-B2707-1

5·16 B-2707 Subcontractor Geographic Distribution

Potential Suppliers

ABEX Corporation	Oxnard, California	E
ABEX Industries of Canada, Ltd	Montreal, Canada	E
AC Electronics Division	Milwaukee, Wisconsin	E
Aerojet-General Corporation	Sacramento, California	P
AiResearch Manufacturing Co	Los Angeles, California	E
	Phoenix, Arizona	E
American Cyanamid Co	Havre DeGrace, Maryland	N
ARMETCO	Worcester, Ohio	T
Astro Met	Worcester, Ohio	T
Automation Industries	Abilene, Texas	M
AVCO Corporation	Nashville, Tennessee	A
The Bendix Corporation	Teterboro, New Jersey	E
	North Hollywood, California	E
	South Bend, Indiana	L
	Baltimore, Maryland	E
Bertea Products	Pasadena, California	E
Blades Manufacturing	Rector, Arkansas	M
Blanchat Machine Co.	Wichita, Kansas	M
A. B. Boyd	Portland, Oregon	N
Brunswick Corporation	Marion, Virginia	E
Carlton Forge Works	Paramount, California	T
Carpenter Steel	San Diego, California	T
Cleveland Pneumatic Tool Company	Cleveland, Ohio	E
Coast Manufacturing and Supply	Livermore, California	N
Comet Tool & Die	St. Louis, Missouri	M
Coors Porcelain	Golden, Colorado	N
Corning Glass Works	Corning, New York	N
Crucible Steel Company	Midland, Pennsylvania	T
Curtiss-Wright	Buffalo, New York	T
Curtiss-Wright	Caldwell, New Jersey	E
Dependable Kellering	Livonia, Michigan	M
Dow Corning	Elizabethtown, Kentucky	E
Fairchild Hiller, Republic	Farmingdale, New York	A
General Electric Corporation	Waynesboro, Virginia	E
General Tire and Rubber Company	Akron, Ohio	E
Glassrock Products	Atlanta, Georgia	N
B. F. Goodrich Company	Akron, Ohio	E
Goodyear Tire and Rubber Company	Akron, Ohio	E
Hamilton-Standard Division	Windsor Locks, Connecticut	E
H. M. Harper	Morton Grove, Illinois	T
Harvey Aluminum	Torrence, California	T
A. W. Hecker	Atlanta, Georgia	M
Hewitt-Robins, Ind., Foot Bros.	Chicago, Illinois	E
Hexcel Products Inc	Berkeley, California	N
Honeywell, Inc.	Minneapolis, Minnesota	E
Howmet Corporation, Misco Div.	Whiteall, Michigan	T
Hydraulic Research & Manufacturing Co	Burbank, California	E
Hydro-Aire Division, The Crane Corp.	Burbank, California	E
International Business Machines Corp.	Owego, New York	E
Kanarr Corporation	Kingston, Pennsylvania	M
Kelsey-Hayes Company	Springfield, Ohio	E
Kollsman Instrument Company	Elmhurst, New York	E
Ladish Company	Cudahy, Wisconsin	T
Lafiell Mfg. Co.	Santa Fe Springs, California	T
Lear Siegler, Inc	Cleveland, Ohio	E
Libby-Owens-Ford Glass Company	Toledo, Ohio	E
Litton Industries, Inc	Woodland Hills, California	E
Loud Company	Pomona, California	L
LTV Aerospace Corporation	Dallas, Texas	A
The Marquardt Corporation	Van Nuys, California	E
The Martin Company	Baltimore, Maryland	A
Monsanto Company	St. Louis, Missouri	N
Moog, Inc	East Aurora, New York	E
Motorola, Incorporated	Scottsdale, Arizona	E
Murdock Machine & Engr. Co	Irving, Texas	M
North American Aviation, Inc	Los Angeles, California	A
Northrop Corporation	Hawthorne, California	A
	Palos Verdes, California	T
Nuclear Metals	West Concord, Massachusetts	T
Pittsburgh Plate Glass Company	Pittsburgh, Pennsylvania	E
Precision Castparts Corp	Portland, Oregon	T
Kadin Corp. of America	Los Angeles, California	E
R & D Metals	Kidron, Ohio	T
Raybestos Manhattan	Charleston, South Carolina	N
Reactive Metals, Inc	Niles, Ohio	T
Reisner Metals, Inc	Southgate, California	T
Rohr Corporation	Chula Vista, California	P
Royal Industries, Inc	Pasadena, California	E
Sargent Engineering	Huntington Park, California	E
Simonds Precision Products, Inc	Tarrytown, New York	E
Sperry Phoenix Company	Phoenix, Arizona	L
Steel Improvement & Forge Co	Cleveland, Ohio	T
Sundstrand Corporation	Rockford, Illinois	E
H. I. Thompson Fibre Glass Co	Gardena, California	N
Titanium Metals Corp. of America	Toronto, Ohio	T
TRW, Incorporated	Cleveland, Ohio	E
Vickers, Inc	Troy, Michigan	E
Viking Forge & Steel Co.	Albany, California	T
Western Gear Corporation	Lynwood, California	E
Western Pneumatic	Kirkland, Washington	T
Weston Hydraulics	Van Nuys, California	E
Whittaker, Corporation	Chatsworth, California	E
Wolverine Tube	Allen Park, Michigan	T
World Tool & Engineering	Minneapolis, Minnesota	M
Wyman-Gordon Co	Worcester, Massachusetts	T

E – Equipment
L – Landing Gear
A – Airframe
P – Power Package
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V1-82707-1

Warranty Program

Recognizing the substantial financial risk inherent in introducing and operating a complex system like the supersonic transport, Boeing has developed a comprehensive warranty program aimed at minimizing the financial risk to the airlines. During the Phase II-C development period for the SST, Boeing has solicited the airlines for their recommendations. These recommendations, Boeing's subsonic warranty experience, a comprehensive analysis of supersonic warranty needs, and the presently planned prototype development program form the base for the Model B-2707 warranty program.

The initial subsonic warranty program, offered to the airlines with the introduction of subsonic jets in 1958, provided a material and workmanship warranty of 1 year or 2,500 flight hours and a design warranty of 6 months or 1,250 flight hours. By 1964, service experience made it possible to double this coverage and, in addition, to introduce a service life policy covering primary structural components covering the period subsequent to the expiration of the design warranty. Continuing the policy of warranty improvement, major landing gear components were added to the service life policy in 1966. Based upon SST studies, a pilot component reliability warranty program is now being introduced for the Model 747.

The Model B-2707 warranty program will provide the following as a minimum:

- Design Warranty—18 months or 5,000 flight hours
- Material and Workmanship Warranty—2 years or 6,600 flight hours
- Structures Service Life Policy—10 years or 33,000 flight hours
- Component Service Life Policy—5 years
- Direct Labor Cost Reimbursement Policy—Duration of applicable warranty
- Spares Support Policy—Duration of the component service policy
- Vendor Warranties—Comparable to Boeing warranties

The design warranty provides the customer with recourse for defects or faults in design that become apparent during the warranty period. The material and workmanship warranty provides for the replacement of defective parts at no charge where discovered prior to the expiration of the warranty period. Boeing's share of the cost for correction or replacement varies from 100 percent at the time of airplane delivery to 33$^1/_3$ percent at the end of the policy period of 10 years. The component service policy will cover Boeing-designed selected high-value equipment components essential to flight dispatch and will cover the customer for 5 years after delivery of the airplane. The direct labor cost reimbursement policy will provide the airline reimbursement of its direct labor costs for the repair or correction of design or material and workmanship defects determined to be the responsibility of Boeing.

The spares policy provides for the consignment of spares to support components experiencing unsatisfactory reliability.

There have been occasions where in-service problems have arisen that were beyond the warranty period specified in the contract. Each claim from the airline was reviewed individually and corrective action taken where justified, notwithstanding the contractual aspect of the warranty. It has also been Boeing policy to improve and expand warranties as justified by in-service experience. These policies will be continued during the B-2707 program.

Costs

COST AND SALES PRICE SUMMARY

The summary cost and sales price for the program, derived in accordance with FAA economic model ground rules, are shown in Fig. 7-1. One of the key elements for Phase III is the airframe cost estimate which is included in the signed contract submitted with this proposal.

The Boeing Company has great confidence in its ability to accomplish all required work within the proposed cost of $623 million. The depth of the work statement permitted the development of comprehensive plans and estimates which were the basis of the January 1966 cost baseline submission, and continued forward to form the basis for this submission. The most significant cost adjustment from the January 1966 Phase III cost estimate ($435 million) results from the preproduction prototype airplane gross weight change from 510,000 pounds to 635,000 pounds. This change accounts for approximately $100 million of the increase. Escalation for time period dollars, and the scheduling of additional structural and wind tunnel tests to provide greater design confidence, account essentially for the additional $88 million of the increase.

The Boeing Company's $623 million Phase III estimate is austere, but realistic and attainable. In order to provide additional constraints on the Phase III cost objective, which could become meaningless if an overrun resulted in the manufacturer reaching the maximum share ceiling of $100 million, The Boeing Company proposes that any arbitrary ceiling be removed, and that program overruns be shared 75 percent Government/25 percent Boeing to completion.

Phases IV and V costs have been develped on essentially the same concept as described for Phase III. Recognizing the considerable unknowns, however, Phase V costs forecasted for the 1976 time period have been increased by 20 percent for contingencies, interest, and profit.

7•1 *Cost and Sales Price Summary*
(Millions of Dollars)
(FAA Economic Model Ground Rules)

	GE Engine			P&W Engine		
[redacted]	[redacted]			[redacted]		
Phase III............	623	281	904	623	290	913
[redacted]	[redacted]			[redacted]		

Note: Phase IV and V costs are in 1967 Dollars.